ANALYZING THE IMPACT OF BIOFUEL INDUSTRY ON THAILAND'S ECONOMY

BASED ON INPUT-OUTPUT MODEL

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งานวิจัยนี้มุ่งเน้นที่จะศึกษาผลกระทบของอุตสาหกรรมเชื้อเพลิงชีวภาพ ได้แก่
เอทานอลและไบโอดีเซลต่อเศรษฐกิจของประเทศไทย การวิเคราะห์โดยใช้ตารางปัจจัยการผลิต
และผลผลิตของประเทศไทย ในช่วง 10 ปีที่ผ่านมาแผนพัฒนาพลังงานทดแทนของประเทศ
ไทย มีบทบาทสำคัญในการกำหนดนโยบายและส่งเสริมอุตสาหกรรมเชื้อเพลิงชีวภาพ
แผนมุ่งเน้นที่การเพิ่มความมั่นคงด้านพลังงานภายในประเทศ โดยเพิ่มการใช้แหล่งพลังงาน
ทางเลือกซึ่งเป็นการทดแทนการนำเข้าเชื้อเพลิง อย่างไรก็ตามความท้าทายหลัก
คือความสามารถในการแข่งขันด้านราคา ซึ่งต้องมีการอุดหนุนราคาเนื่องจากเชื้อเพลิงชีวภาพ
มีต้นทุนที่แพงกว่าเพื่อรักษาตลาดในอุตสาหกรรม ดังนั้นวัตถุประสงค์หลักของการศึกษา
ครั้งนี้คือการมุ่งเน้นไปที่ผลกระทบของเชื้อเพลิงชีวภาพในทุกภาคส่วนและผลผลิตรวมของ
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และผลผลิตรวมของเศรษฐกิจไทย อย่างไรก็ตามรัฐบาลจะได้รับรายได้จากภาษีที่ลดลง
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THIPRUEDEE LIMCHAIKIT: ANALYZING THE IMPACT OF BIOFUEL INDUSTRY ON THAILAND'S ECONOMYBASED ON INPUT-OUTPUT MODEL. ADVISOR: ASST. PROF. THITISAK BOONPRAMOTE, PH.D. CO-ADVISOR: PONGSUN BUNDITSAKULCHAI, PH.D.

This research tries to examine the impact of the biofuel industry focusing on ethanol and biodiesel on Thailand's economy. It uses input-output analysis. In the past 10 years, Thailand's Alternate Energy Development Plan (AEDP) has played a significant role in launching policies and promoting the biofuel industry. The plan focuses on increasing internal energy security by increasing the use of alternate sources of energy which is a perfect replacement for the importation of fuels. However, the main challenge is price competitiveness which requires subsidization to sustain its market in the industry. Therefore, the main objective of this study is to focus on the impacts of biofuels on every sector and the total output of the Thailand economy. The biofuel industry can increase the household income and the total output of the Thailand economy. However, the government might slightly loose on value-added tax but that benefit is channeled to household income. This calls for collective efforts in promoting the biofuel industry.

Field of Study:	Energy Technology and Management	Student's Signature	
Academic Year:	2019	Advisor's Signature	
		Co-advisor's Signature	

ACKNOWLEDGEMENTS

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CHULALONGKORN UNIVERSITY

CHAPTER 1

INTRODUCTION

1.1 Background and Statement of the problems

1.1.1 Overview of Biofuel Industry

Biofuel, including Ethanol and biodiesel, are the two most widely used fuel types to replace conventional fuel in many countries, which derived from molasses and cassava for Ethanol and wasted cooking oil, palm stearin, crude palm oil for biodiesel. It can be blended with conventional petroleum fuel to improve its octane level resulting in reduced greenhouse gas emissions. All the biofuel products in Thailand are consuming domestically in the transport section.

Transport is one of the most critical infrastructures in every country. It plays an essential role in economic growth and globalization by locating people, goods, and technologies from one place to another. There are different types of transportation; by air, by sea, and by land. Seventy-six percent of transport energy in Thailand is consumed in the road sector, which is the most significant sector. Mainly energy used by the transport sector comes from petroleum products, which represent 72 percent of the total consumption of petroleum products in Thailand ("Thailand Overview 2018-20," 2018) Not only petroleum uses as energy for the transportation sector, but there is also fuel diversification by blending biofuel or renewable energy sources in gasoline, as mentioned.

The main reasons of blending biofuel into gasoline are to reduce oil importation, as far as independence from imported oil, encouraging agricultural expansion and promoting domestic markets for agricultural commodities, creating rural employment and improving farmer income (Nguyen & Gheewala, 2008) as well as carbon oxide emission reduction. There are several benefits to using biofuel as conventional fuel

substitution, as mentioned. However, biofuel products such as Ethanol and biodiesel price are significantly higher than the unleaded gasoline price at the current situation for both benzene and diesel (2019). The government supports the biofuel industry by subsidizing the retail price of the blended gasoline through oil fund, resulting in gasoline with biofuel blended has lowed retail price for consumer attraction unless the biofuel industry could not survive due to less price competitiveness.

1.1.2 Alternative Energy Development Plan (AEPD) and Current Situation

1.1.2.1 Ethanol

Thailand was the first country in Asia to announce national policies for bioethanol, continuously promote ethanol usage in the country, and give people more confidence in biofuels. The government supports the ethanol industry by structured oil pricing to make retail prices of gasohol lower than ULG or unleaded gasoline retail prices. The State Oil Fund provided price subsidies. The price mechanism shows in **Table 1-1.**

Table 1-1 Gasoline exit-refinery price and retail price (May 2019)

Source: ("Oil Price Structure," 2020)

UNIT:BAHT/LITRE	EX-REFIN. (AVG)	TAX B./LITRE	M. TAX B./LITRE	OIL FUND	CONSV. FUND	WHOLESALE PRICE(WS)	VAT	WS&VAT	MARKETING MARGIN	VAT	RETAIL
ULG	16.2511	6.5000	0.6500	8.0800	0.1000	31.5811	2.2107	33.7918	3.0544	0.2138	37.06
GASOHOL95 E10	16.7649	5.8500	0.5850	2.1200	0.1000	25.4199	1.7794	27.1993	2.2904	0.1603	29.65
GASOHOL91	16.3588	5.8500	0.5850	2.1200	0.1000	25.0138	1.7510	26.7647	2.4442	0.1711	29.38
GASOHOL95 E20	17.3358	5.2000	0.5200	-0.7800	0.1000	22.3758	1.5663	23.9421	2.5214	0.1765	26.64
GASOHOL95 E85	20.5328	0.9750	0.0975	-6.3800	0.1000	15.3253	1.0728	16.3980	4.3850	0.3070	21.09
H-DIESEL	17.3190	5.9800	0.5980	0.2000	0.1000	24.1970	1.6938	25.8908	2.0553	0.1439	28.09
H-DIESEL B20	17.7197	5.1520	0.5152	-4.5000	0.1000	18.9869	1.3291	20.3160	2.5925	0.1815	23.09

Since 2013, unleaded Gasoline 91 octanes were banned and replaced with E10 or gasohol 91, which raised ethanol usage significantly, from 1.3 million liters/day in 2012 to 2 million liters/day in 2013 ("Thailand Overview 2018-20" 2018) AEDP 2015 (2015 – 2036) targeted ethanol consumption 11.3 million liters/day. However, the ethanol consumption in 2018 was 4 million/litter per day, and forecasting the consumption will be only 5.7 million litter/day in 2036 (Thai Oil Group, 2018), which has more than 5 million litter/day gap compared to AEDP target showed in **Figure 1-1**.
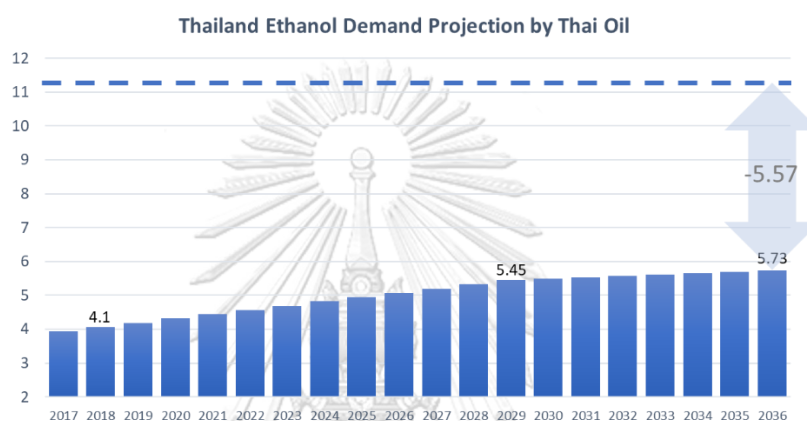
Figure 1-1 Ethanol demand projection VS AEDP target

1.1.2.2 Biodiesel

Biodiesel blending rates started with B2 or 2 percent biodiesel since 2008 and slightly increased the blending ratio until B5 mandatory in 2016. Follow by a mandatory blending rate of B7. The government has a plan to implement the compulsory rate to B10 in 2018 for all diesel sales. Feedstock becomes one of the most critical factors to biodiesel success penetration in the Thai market due to oil palm need more extended time for plantation until harvest, at least 3-4 years. From AEDP biodiesel consumption targets at 5.1 billion litters by 2036 or 14 million litter per day. The current situation is in the same situation as Ethanol, the consumption in 2015 showed only 3.40 million litter per day, which still has a considerable gap consumption left compared to AEDP.

Thailand Biodiesel Demand Projection by Thai Oil
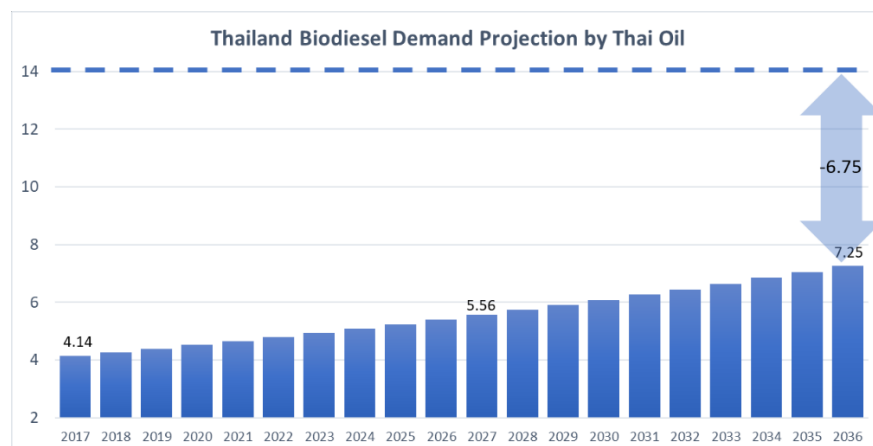
Figure 1-2 Biodiesel demand projection VS AEDP target

1.1.3 Oil Fund

A state oil fund will be used to support domestic retail fuel prices and to stabilize local fuel prices. The oil fund was also used to support biofuel industries such as gasohol and biodiesel in order to attract consumers with lower retail prices and increase the consumption of biofuel to meet the target of biofuel usage according to the alternative energy plan. From the current gasoline price structure shown in **Table 1-1**, the government spent on biofuel subsidizes more than 4.5 billion THB/year.

Using biofuel to replace conventional petrol oil gives many benefits for the country, especially for an agricultural country like Thailand. On the other hand, the main unavoidable disadvantage is the higher production cost, which needs the government to subsidize in this part to be able to compete with conventional fuel or refinery products. This research will study the total output of this biofuel industry that effected Thailand's economic system and to be the country policy adjustment recommendation in the future.

1.2 Research Objective

1) To verify the effect of the biofuel industry as a substitution for conventional fuel on Thailand's economy

2) Study the impact on the tax rate, Income, and Value-Add for biofuel industries

3) To suggest policy recommendation for revising Thailand's Alternative Energy Development Plan (AEPD) in future

1.3 Research Scope

Database from Thailand IO Table in the year 2010 from Thailand's Office of the National Economic and Social Development Council 180x180. Focus sector; all sectors related to biofuel; Ethanol and biodiesel includes Feedstock, Production technology, Product and by-product, GDP and Total Output

Assuming all biofuel products produce and consume in only the transport sector domestically in Thailand.

1.4 Expected Benefit

1) Policy brief/recommendation for adjusting the alternative energy development plan

2) Details of the positive and negative impact of biofuel industry on other sectors

Database with an intermediate transaction for process cost optimization

Baseline analytical tool for other agriculture-based countries in Southeast Asia

CHAPTER 2

LITERATURE REVIEW

2.1 Biofuel Technical Information

2.1.1 Ethanol

Ethanol or ethyl alcohol is simple alcohol with the chemical formula C_2H_6O. Ethanol is sugar or starch-based biofuel made from the fermentation of the starch-based raw material derived from a variety of organic material including biomass and the traditional feedstocks, like corn, sugar, sorghum, wheat crops, and cassava. Fuel grade ethanol intended for blending with unleaded or leaded petrol to use as a spark-ignition automotive engine fuel.

There are three necessary steps for the starch-based ethanol production process. The first step is to break down starch typically from cassava into dissolved sugars. This step includes milling, cooking, and liquefaction. Enzymes will convert this starch into simple sugar—secondly, fermentation process. After the starch is hydrolyzed into sugar, the sugar will be fed into a fermentation vessel to produce Ethanol. During fermentation, yeast converts the glucose (sugar) into Ethanol. The last step is the purification or distillation step, where substances are separated by their boiling point during distillation and further concentrated into high purity ethanol for blending into fuel. For sugar-based Ethanol, the process excludes the hydrolysis step.
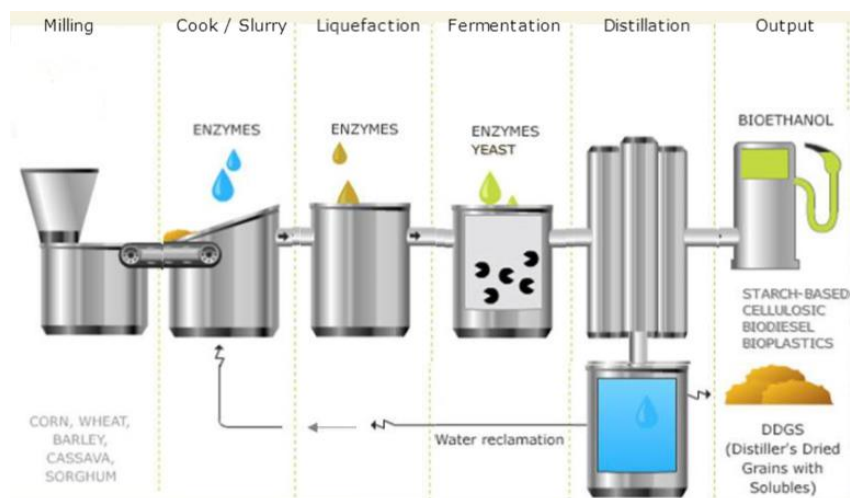
Figure 2-1 Ethanol Production Flow Diagram

In Thailand, commonly divided ethanol producer into three groups related to the feedstock;

1. Cassava ethanol plant

2. Molasses and cane juice ethanol plant

3. Cassava/Molasses ethanol plant for the plants that able to use both feedstocks

Table 2-1 Ethanol producer in Thailand

Source: ("Ethanol Producer in Thailand,")

Producer	Feed Stock	Installed Capacity ((liters/day)
1. Thai Agro Energy PCL	Molasses	150,000
2. KTIS Bioethanol Co., Ltd	Molasses	230,000
3. Thai Sugar Ethanol Co., Ltd	Molasses	100,000
4. Mitrphon Biofuel Co., Ltd (Chaiyaphum)	Molasses	500,000
5. Mitrphon Biofuel Co., Ltd (Kalasin)	Molasses	230,000
6. Mitrphon Biofuel Co., Ltd (Kuchinarai)	Molasses	320,000
7. Mitrphon Biofuel Co., Ltd (Danchang)	Molasses	200,000
8. K.I Alcohol Co., Ltd	Molasses	200,000
9. KSL Green Innovation PCL	Molasses	150,000
10. KSL Green Innovation PCL. (Bo Phloi)	Molasses	300,000
11. Thai Roong Ruang Energy Co., Ltd	Molasses	300,000
12. Maesot Green Energy Co., Ltd	Cane Juice	230,000
13. Sapthip Green Energy Co., Ltd	Cassava	200,000

Producer	Feed Stock	Installed Capacity ((liters/day))
14. Thai Ethanol Power PCL.	Cassava	130,000
15. Taiping Ethanol Co., Ltd	Cassava	150,000
16. PSC Starch Product PCL	Cassava	150,000
17. E85 Co., Ltd	Cassava	500,000
18. Ubon Bio Ethanol Co., Ltd	Cassava	400,000
19. Bangchak Bioethanol Co., Ltd	Cassava	150,000
20. TPK Ethanol Co., Ltd	Cassava	340,000
21. Fakwantip Co., Ltd	Cassava	60,000
22. Impress Ethanol Co., Ltd	Cassava	200,000
23. Rajburi Ethanol Co., Ltd	Cassava/Molasses	150,000
24. ES Power Co.,Ltd	Cassava/Molasses	150,000
25. Thai Alcohol PCL	Cassava/Molasses	200,000
26. Thai Agro Energy PCL	Cassava/Molasses	200,000
Total installed Capacity		5,890,000

2.1.2 Biodiesel

Biodiesel (B100) can be produced from vegetable oil, animal fats, and used cooking oil. The production process converts smaller molecules to an ethyl ester and methyl ester, products that can be used in place of regular diesel. The fuel is produced by transesterification—a process that converts fats and oils into biodiesel and glycerin (a coproduct) showed in **Figure 2-2**
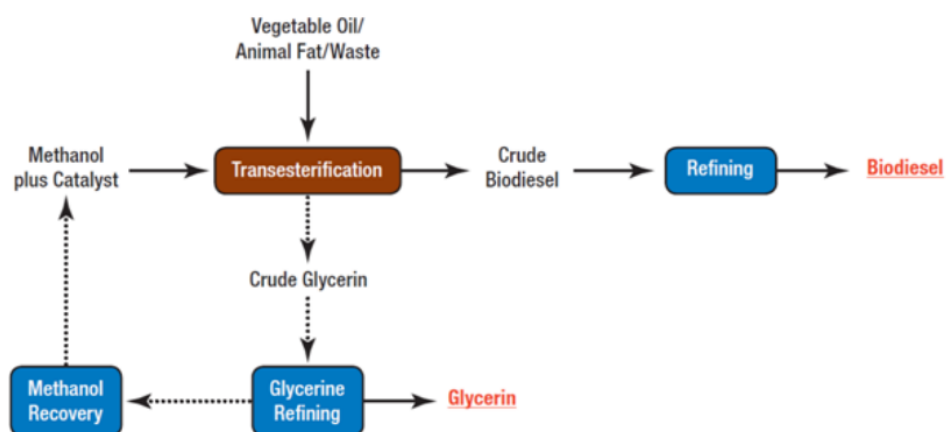
Figure 2-2 Biodiesel Process Flow Diagram

This chemical reaction converts an ester from waste vegetable oil or animal fat into a mixture of esters of the fatty acids that makes up the oil or fat. Biodiesel is obtained from the purification of the combination of fatty acid methyl esters (FAME). A catalyst is used to accelerate the reaction. According to the catalyst used, transesterification can be necessary, acidic or enzymatic, the former being the most frequently used. Animal and plant fats and oils are composed of triglycerides, which are esters formed by the reactions of three free fatty acids and the trihydric alcohol, glycerol. In the transesterification process, the added alcohol (commonly, methanol or Ethanol) is deprotonated with a base to make it a stronger nucleophile. Under normal conditions, this reaction will proceed either exceedingly slowly or not at all, so heat, as well as catalysts (acid and/or base), are used to speed the reaction. Triglycerides are reacted with an alcohol such as Ethanol to give ethyl esters of fatty acids and glycerol showed in **Figure 2-3**

Figure 2-3 Chemical Reaction of Biodiesel

In Thailand there are many feedstock types can be able to use as a feedstock to produce biodiesel includes vegetable oil, crude palm oil (CPO), palm stearine, deodorized palm oil (RBDPO) and deodorized palm stearine (RBDPS)

Table 2-1 Biodiesel producer in Thailand

Source:

Producer	Feed Stock	Installed Capacity (liters/day)
1. Bangchak Petroleum PCL	Vegetable Oil, CPO, RBDPO	50,000
2. Energy Absolute PCL	Palm Stearine	800,000
3. Patum Vegetable Oil Co., Ltd	RBDPO, RBDPS, CPO	1,400,000
4. GI Green Power Co., Ltd	Palm Stearine	200,000
5. A I Energy PCL	RBDPO, RBDPS	500,000
6. Verasuwan Co., Ltd	Palm Stearine	200,000
7. Global Green Chemical PCL	CPO	1,028,600
8. New Biodiesel Co., Ltd	CPO	1,000,000
9. Absolute Power P Co., Ltd	RBDPO	300,000
10. Bio Energy Plus 2 Co., Ltd	Palm Stearine	200,000
11. Bio Synergy Co., Ltd	Vegetable Oil	30,000
12. Bangchak Biofuel Co., Ltd	CPO, RBDPO	810,000
Total		6,518,600

2.2 Research Methodology

To analyze the effect of biofuel industry to Thailand's economic system by using the analysis model, in general, there are three analysis models commonly use are;

1) Net Cost Analysis

2) Multiple Regression Analysis

3) Input-Output Analysis

There are four factors to identify which analysis model is the most suitable for this data analysis. The following guidelines are generally accepted that can be able to locate a reliable tool (Maruyama, 2014 #9) includes;

1) Reliable – a tool gives accurate result and be able to recalculate and generate the same result

2) Sectoral disaggregation – the analysis needs to separate into each related sector to identify the impact on each sector for this study

3) Transparency - analysis method, model hypothesis and how the analysis results should be related and easy to understand, even for people outside of this field

4) Data Requirement – data set required could be challenging to make this research successful

Table 2-2 Reliability comparison between different analysis tools

	Net Cost Analysis	Multiple Regression	Input-Output Analysis
Reliable	Medium	Medium	Medium
Sectoral Disaggregation	No	No	Yes
Transparency	Medium	Medium	Medium/High
Data Requirement	Medium	High	Medium

Input-Output analysis is selected to use for this research from high transparency and sectoral disaggregation. IO analysis is commonly used for estimating the impacts of positive or negative economic shocks and analyzing the ripple effects throughout an economy and generally constructed from observed economic data for a specific geographic region.

Figure 2-4 Input–Output Transactions Table

Source: ("Biodiesel Producer in Thailand," 2020)

The information used in input-output analysis shows the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself, and others felt as consumers—this necessary information from which an input-output model contained in an interindustry transactions table. The rows of the table describe the distribution of a producer's output throughout the economy. The columns represent the composition of inputs required by an industry to produce its output. The additional rows, labeled Value Added, account for the other (non-industrial) inputs to production, such as labor, depreciation of capital, indirect business taxes, and imports.

This structure of the input-output transactions table will be able to identify the impact of the biofuel industry to other industries, for example, sugar refineries, cassava, and oil palm. However, in 180x180, IO Table does not include biofuel section, Molasses-Ethanol, Cassava-Ethanol, and Biodiesel industries that need to be created in order to assess the impacts of biofuel in Thailand.

2.3 Literature Review

AEDP Plan is currently implementing in Thailand to emphasize the use of renewable and alternative energy. Follow by the AEDP plan, the government is targeting an increase in ethanol consumption from 3.21 million liters per day in 2015 to 11.30 million liters per day by 2036 ("Ethanol Producer in Thailand," 2020) and targeting 14 million litter per day for biodiesel.

2.3.1 Ethanol

The government promotes the use of gasohol through price incentives and the mandate to blend all gasoline with 10 percent ethanol to help farmers and increase agriculture products price. Silalertruksa, Gheewala (2011) studied the benefit of blending bioethanol in gasoline. The current E10 mandate to promote bioethanol in a developing country such as Thailand has a significant effect on the country. The positive externalities such as GHG emissions reduction, employment generation, GDP

development, and trade balance improvement. ("Biodiesel Producer in Thailand," 2020) Silalertruksa, Gheewala, Hünecke and Fritsche (2012) said the overall impact of ethanol production in Thailand in the year 2022 followed by the goal on biofuels development of the 15 years alternative energy development plan (2008-2022) are the employment generation of around 238,700-382,400 person per year, 150 M$ additional GDP, imported goods worth 1583 M$ but 2547 M$ of import would be saved if compared to petroleum fuels. The study uses the data source for IO analysis with 180x180 format of 2005 by the National Economic and Social Development that relevant to biofuel production. (Selltiz, C., Jahoda, M., Deutsch, M., & Cook, S. W., 1959)

Suthin Wianwiwat, John Asafu-Adjaye, (2012; 2013) develop a CGE model of Thailand's economy and analyze the macroeconomic and sectoral impacts of implementing biofuel promotion policy. The study results indicate that, in general, all the bio-liquid fuel promoting policies are likely to have an adverse effect on real output in the short-run, leading to a decline in aggregate employment. However, in the long-run, there is a positive impact on real GDP via an increase in total investment resulting from an increase in domestic saving, an improvement in the trade balance, and a general increase in sectoral output.

It has been proved that bioethanol has positive impacts on Thai's socio-economy. However, the current ethanol consumption is still too low compared with the target. In 2018, ethanol consumption was 4.2 million per day (Ministry of Energy, 2015) and forecasting in 2036, the ethanol consumption will be 5.3 million litter per day (Silalertruksa, T. et al., 2011) This forecast shows that it is impossible to meet the AEDP target. Three possible limitations could be obstructed to bioethanol implementation; feedstock limitation, irrigation system, and ethanol mandate policy.

2.3.2 Biodiesel

Not only Ethanol was used as conventional fuel replacement; biodiesel is also being uses to replace diesel fuel in the transportation section. Siriwardhana, Opathella, and Jha mention many benefits of biodiesel affect Thailand's economy and socio-economy. The study mentioned that Thai energy imports account for 50% of the total primary energy supply, and crude oil accounts for 70% of the total energy imports. Petroleum products imports accounted for 9.0% of Thailand's GDP. More than 60% of Thailand's vehicles use diesel as fuel. Diesel consumption increased at an even faster pace, from 15,285 million liters in 1998 to 18,710 million liters, it is expected to rise to 31,000 million liters in 2012. Thai government's bio-diesel development plan, which contributes to a part of petrol-diesel, will reduce the oil dependency. The introduction of B20 (a mixture of 20% biodiesel and 80% diesel) would reduce CO_2 by 12.6%, HC by 11%, PM by 18%, and cancer igneous substances. In Thailand, as a net oil importer, bio-diesel helps to diversify the fuel supply in the transport sector and to increase national energy security. (Siriwardhana, M., Opathella G. K. C., & Jha, M. K., 2009)

2.3.3 Biofuel (Both Ethanol and biodiesel)

R. Bell, Silalertruksa, Gheewala and Kamens also studied the net cost of biofuels in Thailand by evaluated costs and benefits of internal factor, which is produced and external includes environmental, social, etc. and distributed tax cost. The domestic production of biofuel is calculated to be 9.5 billion THB (317 million USD) more expensive than importing the equivalent amount of petroleum. The environmental benefits from GHG savings as well as losses due to increased ground-level ozone formation and government expenditure to support the biofuel industry yield a total "net cost" of 8.6 billion THB or 121 THB (4.04 USD) per capita for the year 2011. This result is contextualized with the (non-monetized) consideration that although biofuels are somewhat more expensive in the short term, their domestic production allows virtually all

of the money to stay within the Thai economy as opposed to being sent abroad. This research is strongly recommending the government to support the consumption of biofuel according to this positive result. (Bell, D. R., Silalertruksa, T., Gheewala, S. H., & Kamens, R., 2011)

From the past studies related to the biofuel industry are all showed the positive side of this industry, and some researches also include the cost of environmental impacts, which are not a tangible cost that government needs to spend. However, the negative side includes current government subsidization through the national oil fund, and the conventional fuel replacement also needs to be considered. This study will combine both positive and negative impacts on the Thai economic system and find out the total output for the whole economic system.
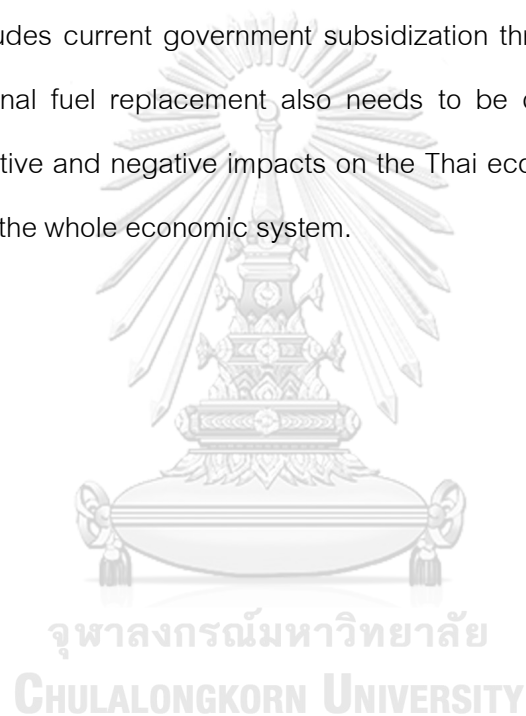
CHAPTER 3

RESEARCH METHODOLOGY

3.1 Input-Output Table and Leontief Inverse

The input-Output table is fundamental information describing the side behavior of an economic system, concerns the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself, and others felt as consumers. This necessary information from which an input-output model is developed contained in an interindustry transactions table or intermediate transaction. Each row describes the distribution of a producer's output throughout the economy. The column represents the composition of inputs required by a particular industry to produce its output showed in **Table 3 1.**

Table 3-1 Input-Output Table

Producers	Producer as consumers					Final Demand	Total Output
	1	$\cdots$	j	$\cdots$	n		
1	z_{11}	$\cdots$	z_{1j}	$\cdots$	z_{1n}	f_1	x_1
2	z_{21}	$\cdots$	z_{2j}	$\cdots$	z_{2n}	f_2	x_2
$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$
n	z_{n1}	$\cdots$	z_{nj}	$\cdots$	z_{nn}	f_n	x_n
Value Added	v_1	$\cdots$	v_j	$\cdots$	v_n		

Where z_{ij} represents transactions between pairs of sectors from each sector i to each sector j. $i = 1, 2, \ldots, n$ shows intermediate input as producers industries $j = 1, 2, \ldots, n$, which consider as intermediate demands between sectors. Assume that the economy can be categorized into n sectors.

f_i represents final demand for each sector, record the sales by each sector to final markets for their production

v_i represents value-added of producers, account for the other (non-industrial) inputs to production, such as labor, depreciation of capital, indirect business taxes, and imports.

x_i is the total output of the production sector i, and by f_i the total final demand for sector i's product, the accounting balance is described as follows. Which sector i distributes its product through sales to other sectors and to final demand.

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_i \tag{3-1}$$

Determine lower-case bold letters for (column) vectors and upper-case letter for matrix

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \ \mathbf{Z} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix} \text{ and } \mathbf{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}$$

we can rewrite Equation 3-1 in linear algebra shows in Equation 3-2

$$\mathbf{x} = \mathbf{Zi} + \mathbf{f} \tag{3-2}$$

Where i to represent a column vector of 1's of appropriate n dimension

The total output includes household consumption, private investment, government consumption, and exports.

The assumption of the Input-Output model is as follows

- The raw materials used in the same production sectors are assumed to be the same and assumed to be unsimilar in different production sectors
- In a short period (not more than 3-5 years), raw material used in each production sector is considered as a constant proportion, with no consideration of economy of scale, non-substitutability. As a result, the price needs to be fixed

On the other hand, Input-Output analysis also stipulates no unemployment. Therefore, when demand increases, it automatically leads to an increase in employment.

From the above assumption, Input-Output analysis is that the input required to make a unit of output is constant, regardless of the output level. The production technology can be effectively converting all flow between industries from physical units into a monetary numeraire. Subsequently, the input coefficient can be defined as follows.

$$a_{ij} = \frac{z_{ij}}{x_j} \tag{3-3}$$

The production technology or production function of Input-Output analysis can be described under Leontief production function shows in Equation 3-4

$$x_j = \min\left(\frac{z_{1j}}{a_{1j}}, \frac{z_{2j}}{a_{2j}}, \cdots, \frac{z_{nj}}{a_{nj}}\right) \tag{3-4}$$

Substitution (3-3) into (3-1),

$$x_i = a_{i1}x_1 + \cdots + a_{ii}x_i + \cdots + a_{in}x_n + f_i = \sum_j a_{ij}x_j + f_i \tag{3-5}$$

This equation describes the relationship between the total output of each sector. The notation of a "hat" over a vector denotes a diagonal matrix with the elements of the vector along the main diagonal. Equation 3-3 and 3-5 can be written in a matrix form as follows.

$$\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1} \text{ or } \mathbf{Z} = \mathbf{A}\hat{\mathbf{x}} \tag{3-6}$$

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \tag{3-7}$$

Define $\mathbf{I}$ be the $n \times n$ identity matrix, which has ones on the leading diagonal and zeros elsewhere. Rewrite Equation 3-7 to Equation 3-8

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{f} \tag{3-8}$$

Define $\mathbf{L} = \mathbf{I} - \mathbf{A}^{-1}$ as the inverse of a $(\mathbf{I} - \mathbf{A})$ matrix

where $\mathbf{L} = \mathbf{I} - \mathbf{A}^{-1}$ is known as the Leontief inverse of the total requirements matrix shown in Equation 3-9.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{L}\mathbf{f}$$

(3-9)

From the Leontief inverse equation in Equation 3-9, this will be used as the starting point for this research to study the impacts on biofuel Industry Output to the Thai economy.

3.2 Multiplier

The multiplier is a coefficient that describes the effect on the economy from the change of external factors (Exogenous changes), especially in a difference in the 1 unit of final demand. The effect is divided into three parts:

1. Initial Effect is a change directly from external factors that affect the economy.
2. Total Effect. The total effects can be defined either as the direct and indirect effects
   a. The direct effect is the value of inputs at the various producer, must be used in the production of that products or services in response to external change "directly," considering a 1-unit shift in external factors.
   b. The indirect effect is the impact of the next round, which describes the usage in the production of goods or services in the previous cycle, can be written as $\mathbf{A}^2 + \mathbf{A}^3 + \ldots$

The total output of 1 unit changed is the total sum of initial effect, direct effect, an indirect effect, or is known as the Leontief inverse of the overall requirements matrix shown in Equation 3-10.

$$(\mathbf{I} - \mathbf{A})^{-1} = \underbrace{\mathbf{I}}_{\text{initial effect}} + \underbrace{\mathbf{A}}_{\text{direct effect}} + \underbrace{\mathbf{A}^2 + \mathbf{A}^3 + \cdots}_{\text{indirect effects}}$$

(3-10)

The general structure of multiplier analysis is the estimation of the effects of exogenous changes on

1. outputs of the sectors in the economy

2. income earned by households in each sector because of the new outputs

3. employment generated in each sector because of the new outputs

4. Value-added that is created by each sector in the economy because of the new outputs

An output multiplier for the sector j is defined as the total value of production in all sectors of the economy that is necessary to satisfy 1 unit currency worth of final demand for the sector j's output. The simple output multiplier for the sector j can be written in Equation 3-11

$$m(\text{o})_j = \sum_{i=1}^{n} l_{ij} \tag{3-11}$$

Rewrite to linear algebra equation shows in Equation (3-12)

$$\mathbf{m}(o) = \mathbf{i}'\mathbf{L} \tag{3-12}$$

Where, $\mathbf{i}'$ is a vector of matrix $\mathbf{i}$ or $[1,..,1]$

in general, analysts are more interested in the impact of changing final demand in terms of employment or household income more than the total output of each sector. Income Multiplier is commonly used to analyze the effect of final demand, which is calculated by multiplying Leontief Inverse by the vector of the coefficient of Vector (employment coefficient) as shown in the Equation 3-13

$$\boldsymbol{\varepsilon}' = \mathbf{e}'\hat{\mathbf{x}}^{-1} \tag{3-13}$$

Where $\mathbf{e}'$ is a vector of employment

Income multiplier as shown in the Equation 3-14

$$m(h)_j = \sum_{i=1}^{n} \varepsilon_i l_{ij} \qquad (3\text{-}14)$$

Rewrite the equation to linear algebra equation, as shown in Equation (3-15)

$$\mathbf{m}(h) = \mathbf{\varepsilon'L} \qquad (3\text{-}15)$$

3.3 Sectoral Disaggregation

Before we are able to study the initial effect by using Leontief inverse in equation 3-9, we need to create an Input-Output table that includes biofuel and disaggregate refinery products into each product first. The data resource for this study is from the 2010 Input-Output published by the National Economic and Social Development Board (NESDB) in 180 x 180 sectors. There are two parts of data disaggregation; column-wise and row-wise, which will be discussed in the next session.

The rows and column will be disaggregate to biofuel products and refinery products as follow;

1. Create new cassava ethanol sector
2. Create new molasses ethanol sector
3. Create a new biodiesel sector
4. Gasoline sector disaggregate from refinery products sector
5. Gasohol 95 sector disaggregate from refinery products sector
6. Gasohol 91 sector disaggregate from refinery products sector
7. Gasohol E20 sector disaggregate from refinery products sector
8. Gasohol E85 sector disaggregate from refinery products sector
9. B2 diesel sector disaggregate from refinery products sector
10. B10 diesel sector disaggregate from refinery products sector

11. Other refinery products. All of the other refinery products left after disaggregated.

From the original 180x180 sectors Input-Output table, after disaggregated, the total sector will be 190 x 190 sectors. The methodology of disaggregation will be discussed in the next chapter.

3.3.1 Column-Wise Disaggregation

The column of this Input-Output table needs to be disaggregated to focus on the composition of raw materials and gross value-added expenses in biofuel and refinery products.

3.3.1.1 Total Output

The total output or x of refinery products and biofuel industries are from the actual domestic biofuel production multiply by the average retail price in 2016 from the Ministry of Energy, shown in **Table 3-2**.

Table 3-2 Refinery Products Actual Production, the Year 2016

Refinery Products	Retail Price	Production	Total Production	Ratio Comparison
	THB per Litter	Million Litter	Million THB	%
Unleaded Gasoline	36.28	2,278	82,642	5.49%
Gasohol95	29.01	4,825	139,963	9.31%
Gasohol91	28.73	3,623	104,071	6.92%
Gasohol E20	26.24	2,004	52,594	3.50%
Gasohol E85	20.90	436	9,112	0.61%
B5 Diesel	28.38	26,808	760,856	50.59%
B10 Diesel	25.38	1,411	35,812	2.38%
Kerosene	22.00	2,144	47,168	3.14%
FO 600 (1) 2%S	15.96	2,968	47,369	3.15%
FO 1500 (2) 2%S	15.36	2,968	45,572	3.03%
Jet Fuel	22.00	8,134	178,948	11.90%
Total Production			1,504,107	

Ethanol and biodiesel are able to calculate back from gasohol and diesel production by ratio. Gasohol 95 and Gasohol 91 contain 10% of the Ethanol blended, Galsohol E20 and E85 contain Ethanol blended 20% and 85%, respectively. Similarly, H-Diesel B5 and B10 contain biodiesel blended 5% and 10%, respectively. Biofuel products production is shown in **Table 3-3**, which will be used as a total output for ethanol and biodiesel sectors. Ethanol will be disaggregated into two sectors, related to the feedstock, which is cassava ethanol and molasses ethanol. At present, the Thai production of Ethanol uses molasses, cane juice, and cassava at the ratio of 60: 40. The production of Ethanol from molasses can take advantage of the supply of raw materials, as most producers are largescale players who came from sugar milling business. For Ethanol from cassava, on the other hand, inputs may be affected by shortages given the competition among several consuming industries or the intervention of the government to provide price support for the benefit of producers (Tunpaiboon, 2017)

Table 3-3 Biofuel Products Actual Production, the Year 2016

Biofuel Products	Retail Price	Production	Total Production	Ratio Comparison
	THB per Litter	Million Litter	Million THB	%
Cassava Ethanol	23.70	646.48	15,322	21.3%
Molasses Ethanol	23.70	966.72	22,912	31.8%
Biodiesel	24.17	1,400.00	33,832	46.9%
Total Production			72,065	

The data in the Input-Output table are from the year 2010. However, this production data for both refinery products and biofuel products were from the year 2016. The data needs to be adjusted to be aligned with Input-Output Table by ratio before use. We assumed that the ratio of each refinery products is the same in the year 2010.

3.3.1.2 Biofuel Sector Disaggregation

Another part of column-wise disaggregation is an intermediate input of the biofuel products sector. The reference for the biofuel sector disaggregation is from Brazil's Input-Output table from IBGE, the year 2015. In Brazil, There are no longer any light vehicles in Brazil running on pure gasoline. Since 1976 the government made it mandatory to blend anhydrous Ethanol with Gasoline, fluctuating between 10% to 22% The maid feedstock for Ethanol is cane juice and molasses. Apart from Ethanol, 70 percent of biodiesel produced is currently made from soybean oil, and 17 percent is made from animal fat. The remaining feedstocks used are "others," used cooking oil, and cottonseed oil.(*Thai Oil Annual Report*, 2017). Brazil's intermediate input for the Biofuel sector showed in sector 1992, biofuel production, and the intermediate input shown in **Figure 3-1**.
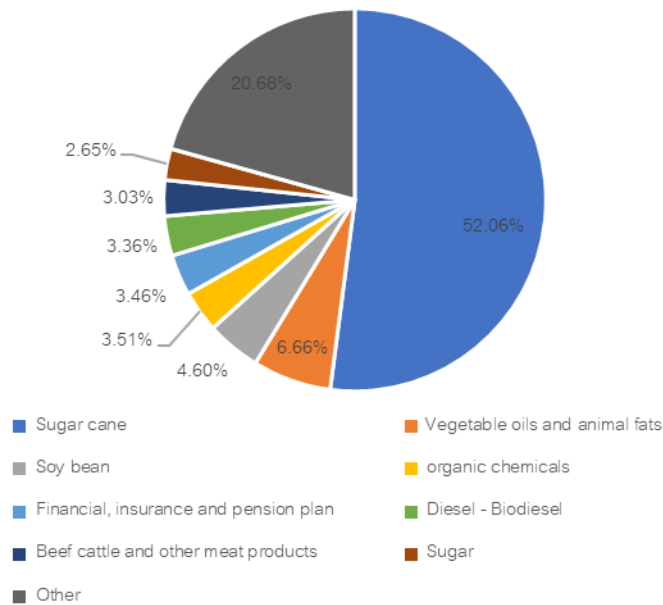
Figure 3-1 Brazil Intermediate Input for Biofuel Production Sector

The most significant intermediate input sector is sugarcane follow by Vegetable oils and animal fats sector and soybean sector. Convert into a ratio of these three sectors shows 53%, 6.6%, and 4.6%, respectively. All these three sectors represent feedstock of the biofuel industry includes Ethanol and Biodiesel. Before the data can be used for Biofuel sectors for Thailand, the data need to be adjusted to be aligned and realistic with Thailand's current situation. We assume that the production technology is mutual between Thailand and Brazil production. The feedstock of each biofuel sectors varies, related to the feedstock as follow;

- Cassava Ethanol, the total feedstock is from cassava sector

- Molasses Ethanol, the feedstock is from molasses, represent in the sugar sector

- Biodiesel, the feedstock is mainly from palm oil, 95% in total, represent in oil palm and coconut and palm oil sector. The other 5% are from different vegetable oil and waste from the eatable oil industry, which describe in other vegetable and animal oils sector. Due to a meager ratio of another feedstock usage of biodiesel, apart from palm oil, this study assumed that 100% of biodiesel production was produced from crude palm oil (CPO)

After adjusted feedstock to be aligned with Thailand's actual data, the intermediate input for cassava ethanol, molasses ethanol, and biodiesel are showed in **Figure 3-2** to **3-4**.

1.6% 1.8% 1.5% 1.4%
2.5%
2.6%
2.6%
2.7%
2.8%

75.2%

6.3%

- Cassava
- Business Service
- Special Industrial Machinery
- Road Freight Transport
- Silo and Warehouse
- Basic Industrial Chemicals
- Unclassified
- Other Insurance Service
- Agricultural Services
- Other Refinery Products
- Other
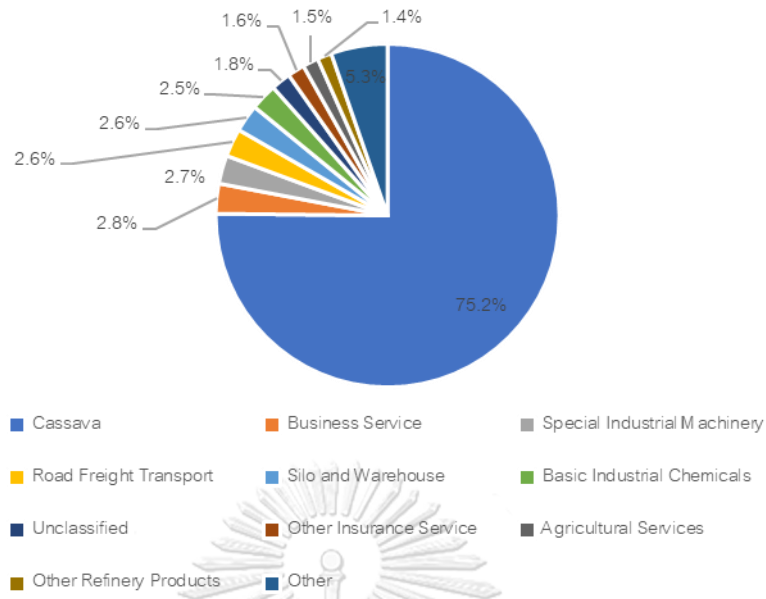
Figure 3-2 Thailand Intermediate Input for cassava ethanol Sector

1.5% 1.4% 1.3%
2.6% 1.8%
2.7%
2.8%
4.3%

73.5%

5.5%

- Sugar
- Basic Industrial Chemicals
- Business Service
- Special Industrial Machinery
- Road Freight Transport
- Silo and Warehouse
- Unclassified
- Agricultural Services
- Other Refinery Products
- B5 Diesel
- Other
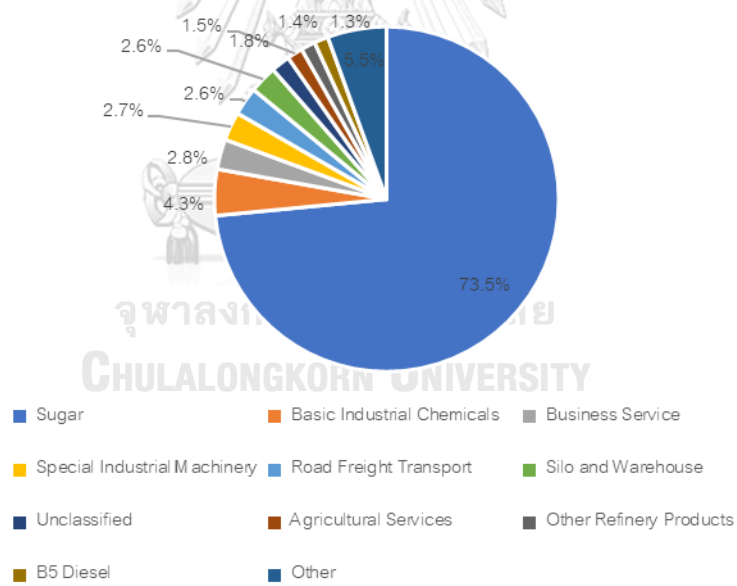
Figure 3-3 Thailand Intermediate Input for molasses ethanol Sector
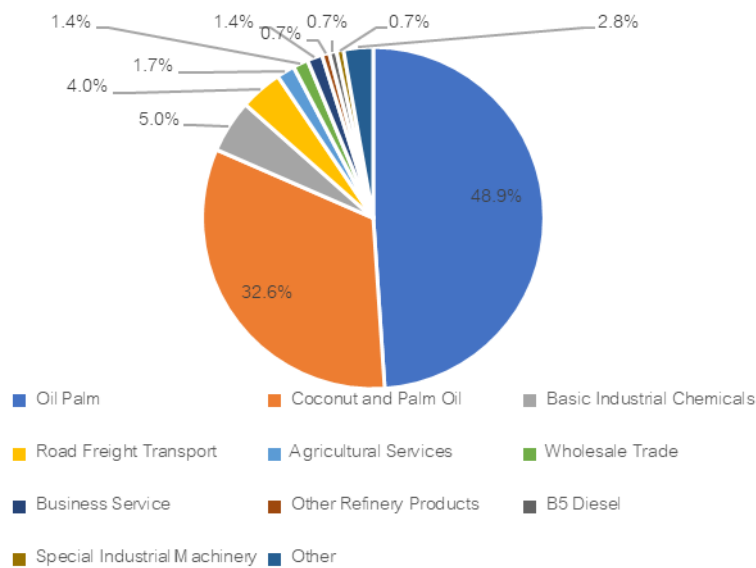
Figure 3-4 Thailand Intermediate Input for molasses ethanol Sector

Lastly, for column-wise disaggregation to make the Input-Output completed, value-added data include Wages and Salaries, Operating Surplus, Depreciation, and Indirect Taxes data are required. To make this table most realistic and rely on actual data for biofuel production in Thailand. The resource of this data is from the financial report from Ethanol production company, Thai Agro Energy Public Company Limited. Intermediate input or direct cost of ethanol production shown The most significant portion of the value-added is operating Surplus, 25.39%, followed by wages and salaries, 6.49% ("Bio-diesel: Initiatives, potential and prospect sin Thailand: A review," 2008) The ratio of the value-added data for ethanol production showed in the **Figure 4-2** Value-Added for biodiesel is slightly different, The most significant portion of the value-added is operating Surplus, 15.14%, followed by wages and salaries, 7.03% The ratio of the value-added data for biodiesel showed in the **Figure 3-5**.
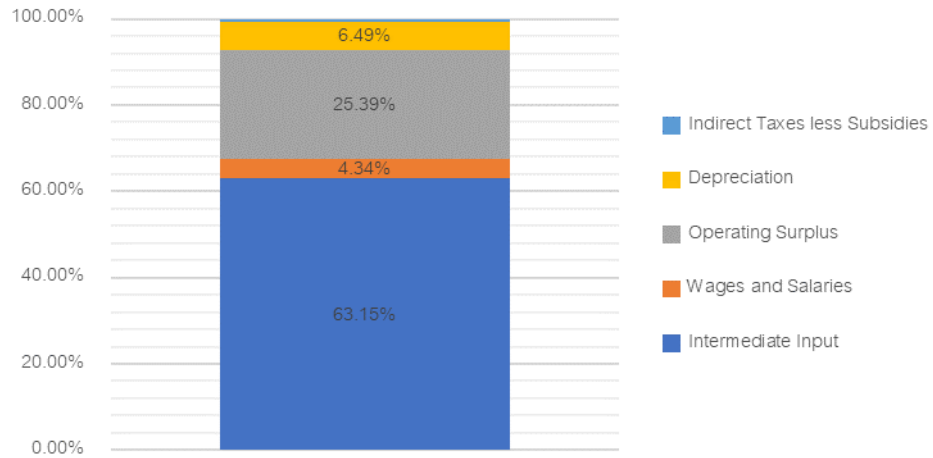
Figure 3-5 Direct and Indirect Cost for Ethanol Production

In addition, with data limitation for biodiesel production. We use the same ratio of direct and indirect cost from the Input-Output table, palm oil sector, and assume that the ratio is equivalent to biodiesel production shown in Figure 3-6.
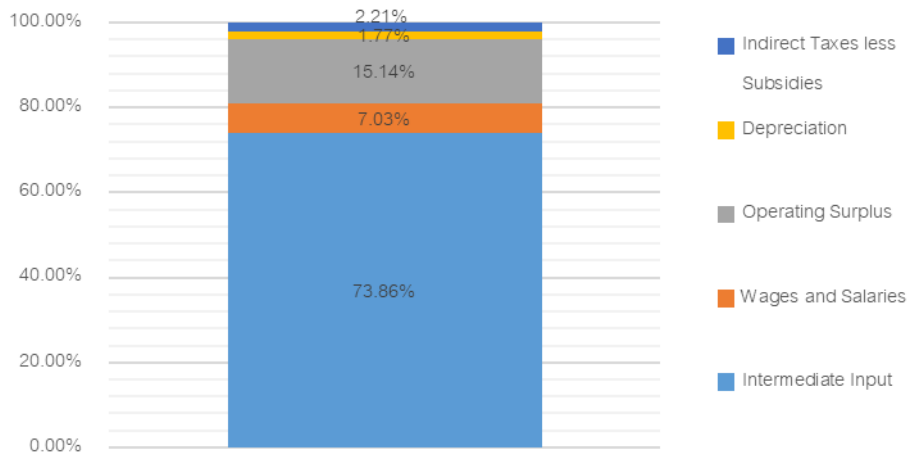
Figure 3-6 Direct and Indirect Cost for biodiesel Production

To confirm the economic structure and biofuel-promoting measures contained in Thailand's AEDP plan. After we completed both intermediate data and value-added data, three new sectors were created.

1. Molasses–Ethanol, split from sugar and distilling blending spirits

2. Cassava–Ethanol, split from tapioca milling

3. Biodiesel, split from oil palm and coconut and palm oil

3.3.1.3 Refinery Products Sector Disaggregation

To study intermediate output and the impact on Thailand's economy from the biofuel sector, the refinery products sector needs to be disaggregated. Hence, all of the biofuel products are sold and blended with refinery products before being sold to consumers. We disaggregated eight sectors from refinery products to Gasoline, Gasohol 95 E10, Gasohol 91 E10, Gasohol E20, Gasohol E85, B5 Diesel, B10 Diesel, and other refinery products. Column-wise disaggregation is straight forward. All the data includes intermediate input, and value-added data were disaggregated in the same ratio of the refinery products sector. The ratio is from the total output, mentioned in 3.3.1.1 for each sector. Once, we assumed that all for the refinery products were produced with the same technology from the same refinery.

After created three new biofuel sectors and disaggregate refinery products, a total column for this Input-Output data will be 190 columns in total (from the original table 180 column)

3.3.2 Row-Wise Disaggregation

After we disaggregated columns into the sector that we are focusing on in this study, the next step is to disaggregation rows of this Input-Output table to study the composition of product sale destinations. For row-wise disaggregation, we also created three new sectors for biofuel products, which are cassava ethanol, molasses ethanol, and biodiesel. And other eight sectors disaggregated from refinery products, which are Gasoline, Gasohol 95, Gasohol91, Gasohol E20, Gasohol E85, B5 Diesel, B10 Diesel, and other refinery products. Correspondingly, the total row will be 190 rows to make this Input-Output table balanced and easy to analyze.

3.3.2.1 Total Output

The total output for rows will be the same data with total output for columns to make the table balanced. The data are shown in session 3.3.1.1.

Private consumption expenditure, government consumption expenditure, gross fixed, capital formation, stock, exportation, and importation are maintaining in the same ratio as original Thailand's Input-Output table.

3.3.2.2 Biofuel Sector Disaggregation

Assuming that 100% of biofuel production was sold to the refinery products industry or all of the biofuel products are raw material to produce all of the refinery products. Ethanol that produces from cassava and molasses was sold to Gasohol 95 and Gasohol 91 in 10% blending ratio, Gasohol E20 in 20% blending ratio, and Gasohol E85 in 85% blending ratio. Biodiesel was sold to B5 diesel in 5% blending and B10 diesel in 10% blending. Apart from the refinery products sector, there will be no ethanol and biodiesel consumption. The table is shown in **Figure 3-7**.

		Gasohol 95	Gasohol 91	Gasohol E20	Gasohol E85	B5 Diesel	B10 Diesel	New Total Intermedite Transaction	NEW Total Demand	Control Total
		...	...	...	...	...	...	...	...	...
Molasses Ethanol	...	6,321,504	3,648,078	4,144,251	4,322,683			18,436,515	18,436,515	18,436,515
Cassava Ethanol	...	4,227,414	2,439,599	2,771,408	2,890,731			12,329,153	12,329,153	12,329,153
BioDiesel	...					24,703,536	2,520,045	27,223,581	27,223,581	27,223,581

Figure 3-7 Biofuel sector consumption

3.3.2.3 Refinery Products Sector Disaggregation

With data limitation for each refinery product consumption or intermediate output, we referenced the data from Japan's Input-Output table from MIC. However, the data needs to be adjusted to be aligned with Thailand's refinery product consumption. Major Japanese industries include automotive, electronic equipment, machine tools, steel, and nonferrous metals, ships, chemicals, textiles, and processed foods (Bell, D. R. et al., 2011). However, the major industries of Thailand are agricultural,

logistics, and communication sectors. With the difference in country-based industries, refinery product usage in terms of gasoline and diesel can be different.

First, we use Japan's Input-Output table with Basic Sector 509 Rows x 391 Columns. Refinery Products for Japan's table are separated into 19 products, shown in Table 3-4. The products that we focused on are Gasoline and Light Oils or Diesel. This Gasoline consumption by each sector will be used for Thailand's gasoline consumption by a ratio. Likewise, light oil consumption will be used for diesel consumption by ratio. However, the data needs to be manually adjusted to be aligned with the Thailand refinery product consumption.

Secondly, with Japan 509 rows Input-Output table, we need to manually match those rows with Thailand's 190 rows for example paper, paperboard, corrugated cardboard, coated paper and building (construction) paper and corrugated cardboard boxes will be combined and match with paper products for Thailand's Input-Output Table, etc.

Table 3-4 Petroleum and Refinery Products Sector for Japan Input-Output Table

Basic Sector Classification (509 Rows x 391 Columns)				
Classification Code				Sector Name
Column Code		Row Code		
2111	-01			Petroleum refinery products (including greases)
		2111	-011	Gasoline
		2111	-012	Jet fuel oils
		2111	-013	Kerosene
		2111	-014	Light oils
		2111	-015	Heavy oil A
		2111	-016	Heavy oil B and C
		2111	-017	Naphtha
		2111	-018	LPG (liquefied petroleum gas)
		2111	-019	Miscellaneous petroleum refinery products

Thirdly, after modified Japan's Input-Output table to 190 rows, the data of gasoline and light oil consumption will be matched and used for gasoline and diesel in

ratios. However, the data needs to be manually adjusted. The consumption of each refinery products between Japan and Thailand are different. The most significant portion for Japan in refinery products is gasoline. However, the most significant portion for Thailand is Diesel, shown in **Figure 3-8**. The main reason is industries that drive the economy of these two countries are different, as mentioned.
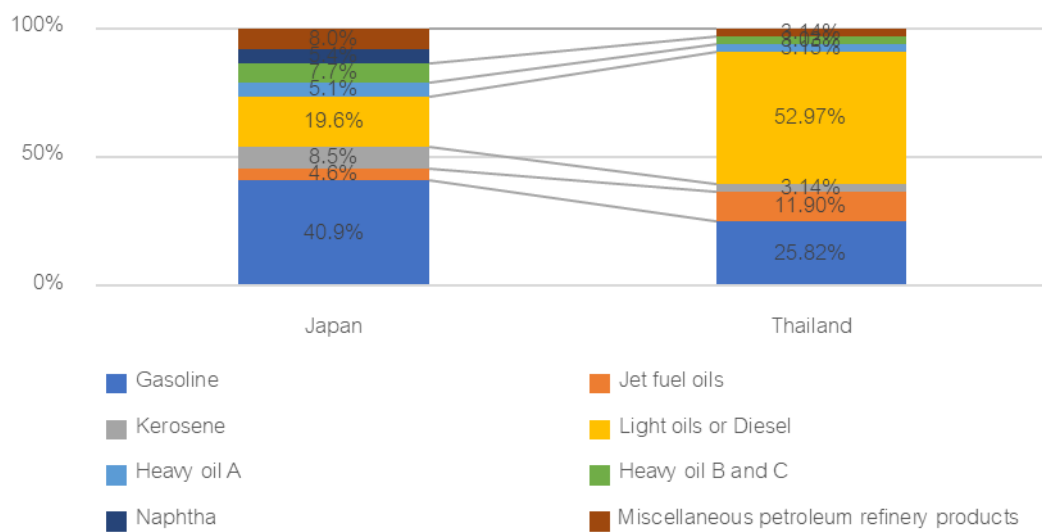
Figure 3-8 Consumption structure of refinery related products

between Japan and Thailand

Focusing on only gasoline and diesel consumption for Japan, the top 10 sectors with the highest consumption shown in **Figures 3-9** and **3-10**.
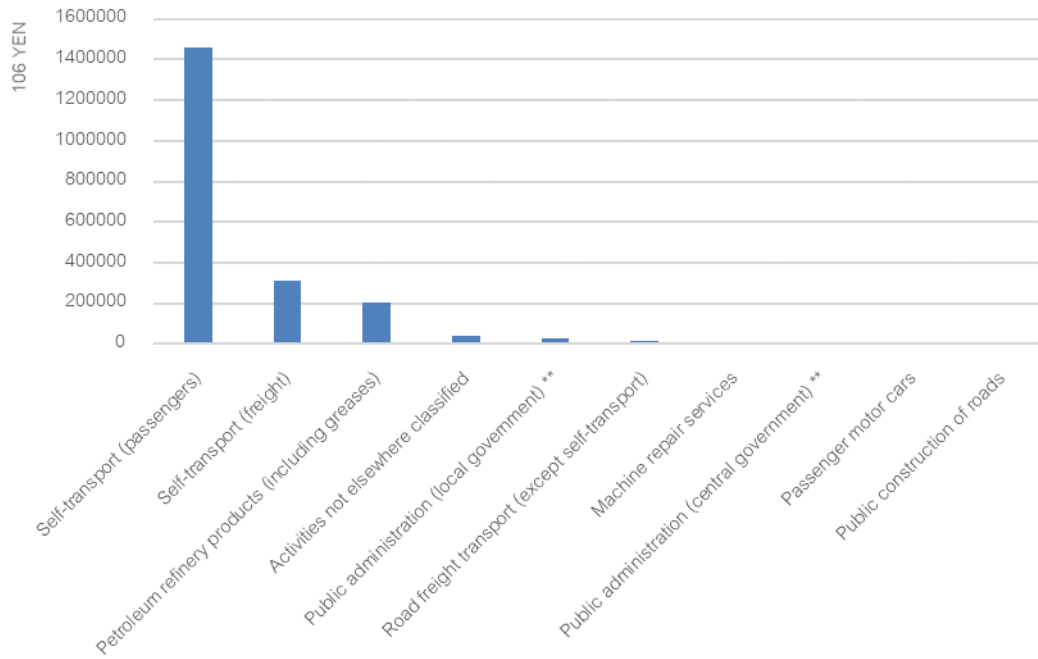
Figure 3-9 Top 10 Industries with highest gasoline consumption
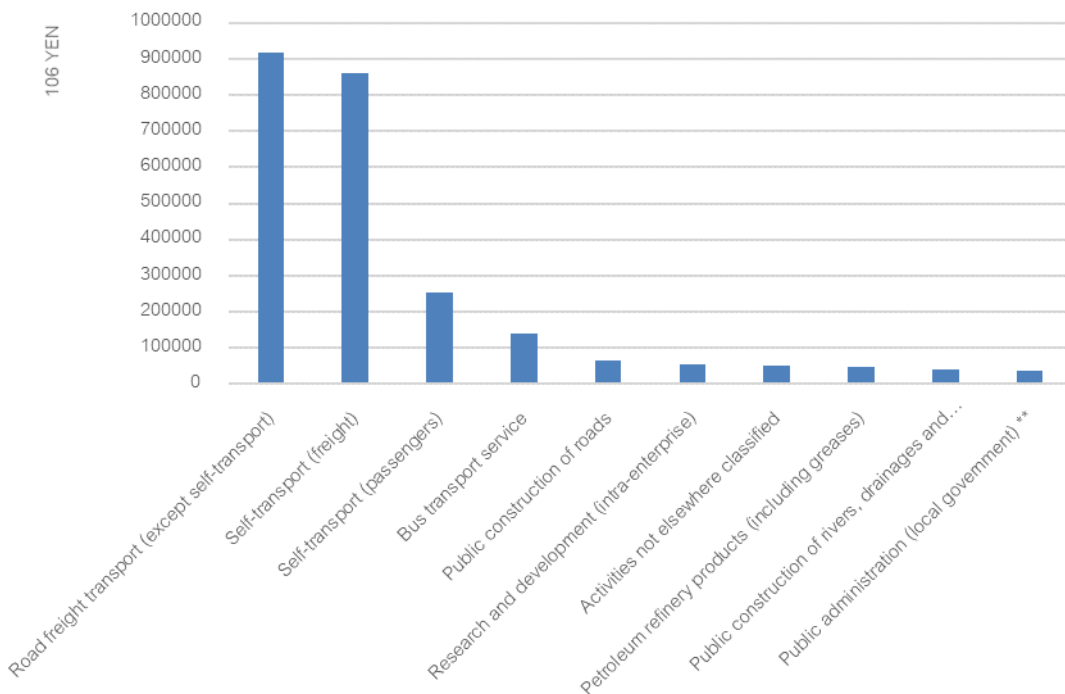
Figure 3-10 Top 10 Industries with highest diesel consumption

Agriculture sectors also need to be manually adjusted. Once agricultural products produce in Japan and Thailand, are different, some agriculture products, e.g., wheat, barley, or sweet potatoes, do not exist in Thailand's Input-Output Table. On the other hand, some Thai agriculture products do not exist in Japan's Input-Output table, e.g., cassava and sugarcane. The methodology to adjust is that we assume 100% of refinery products that appear in the original Thai Input-Output Table go to gasoline and diesel in the same ratio with Japan's table, considering that there are no other refinery products consume in those sectors. The data for Japan and Thailand showed in **Figures 3-10** and **3-11**, respectively.
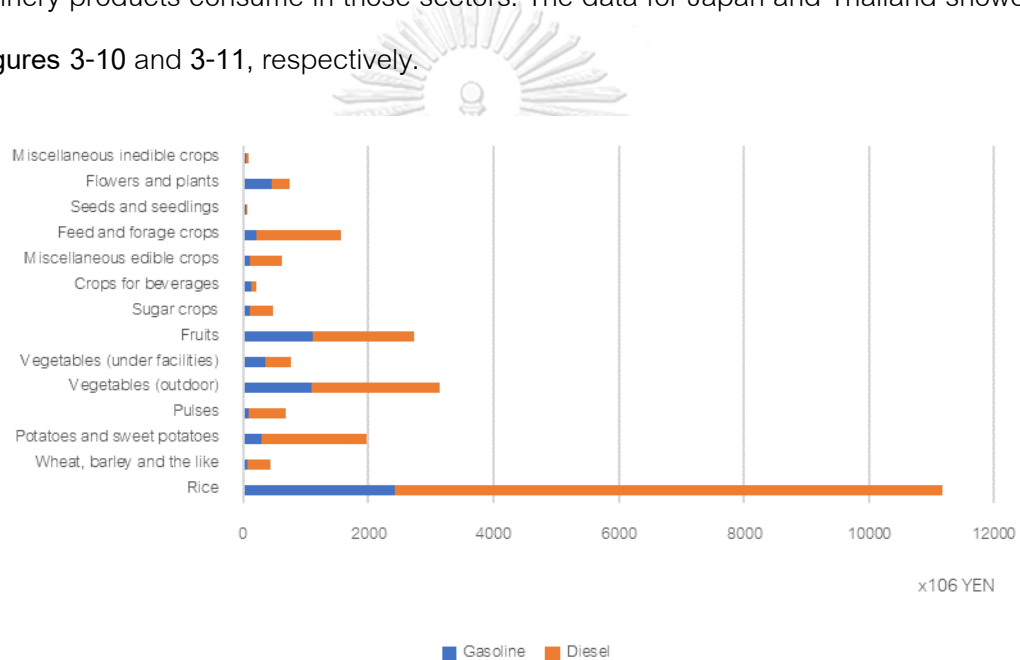
Figure 3-11 Japan gasoline and diesel consumption in agricultural sectors
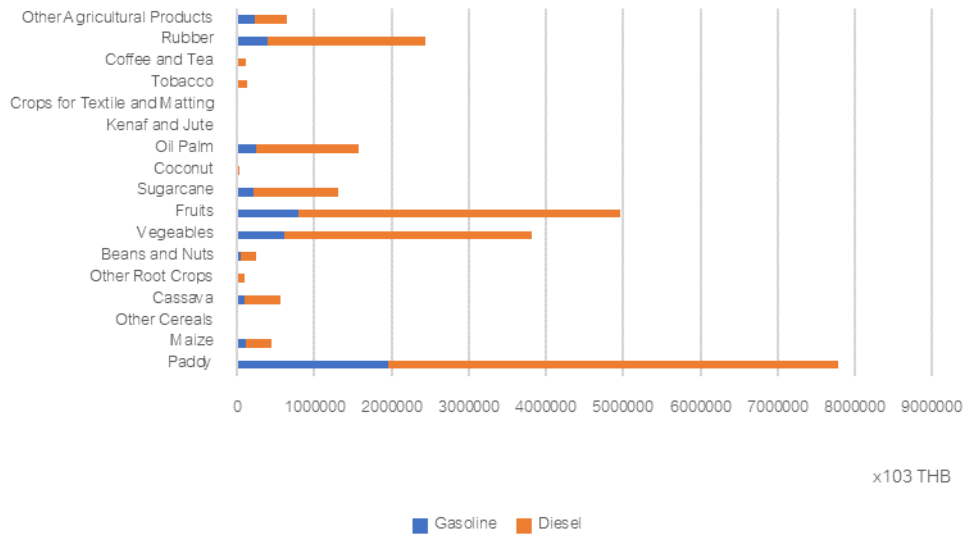
Figure 3-12 Thailand gasoline and diesel consumption in agricultural sectors

Another sector that obviously different between Japan and Thailand is the electricity sector. Of the power sources available, Thailand highly depends on natural gas and coal. Natural gas has mainly driven the growth in the country's electricity output. Apart from natural gas, coal, hydro, and renewable energy, there is a small portion of electricity produced from diesel and fuel oil, approximately 1:1 by ratio. The comparison graph between Japan and Thailand showed in **Figure 3-13**.
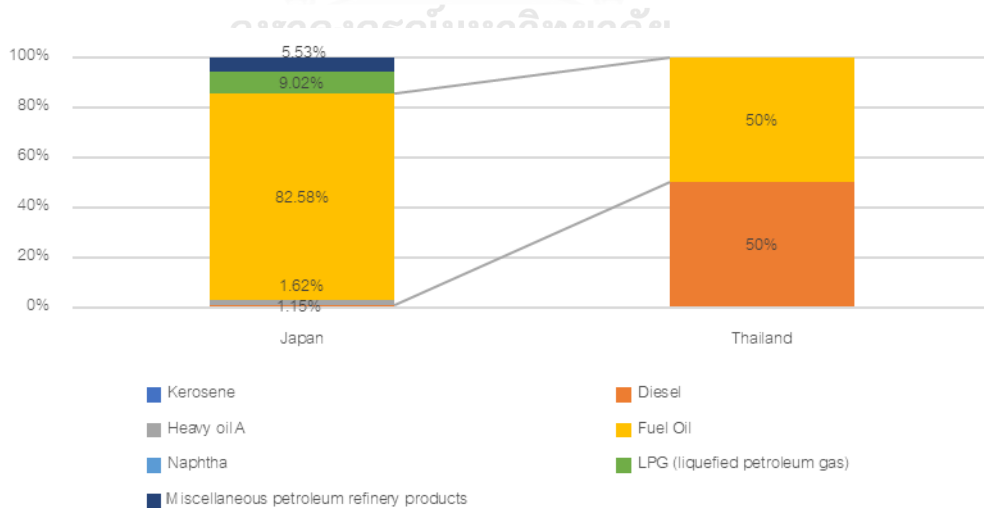
Figure 3-13 Power Plant feedstock comparison between Japan and Thailand

Other sectors apart from mentioned above, the data was adjusted to consider as appropriate. Top 10 sectors with the highest gasoline and diesel consumption for Thailand after the adjustment shown in **Figures 3-14** and **3-15**.
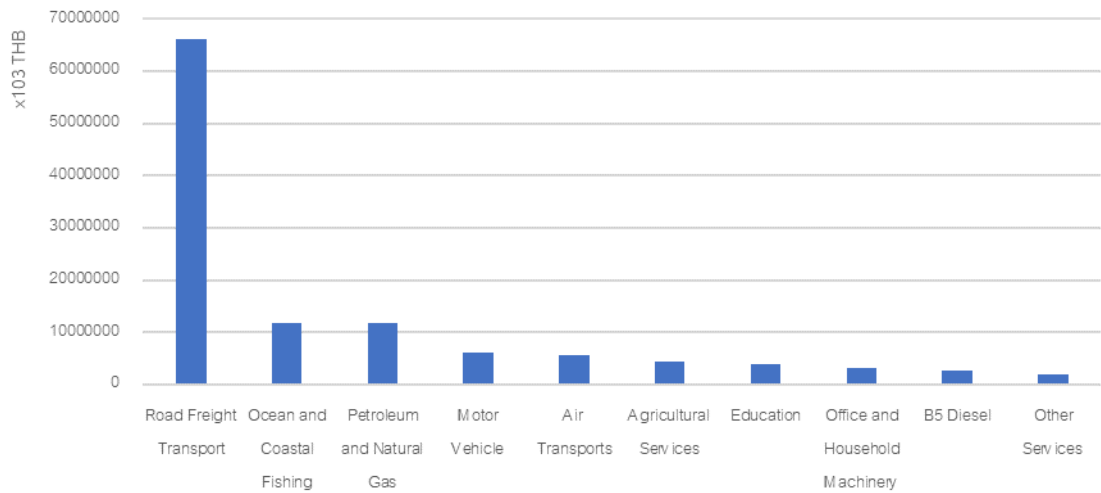
Figure 3-14 Top 10 Industries with highest gasoline consumption
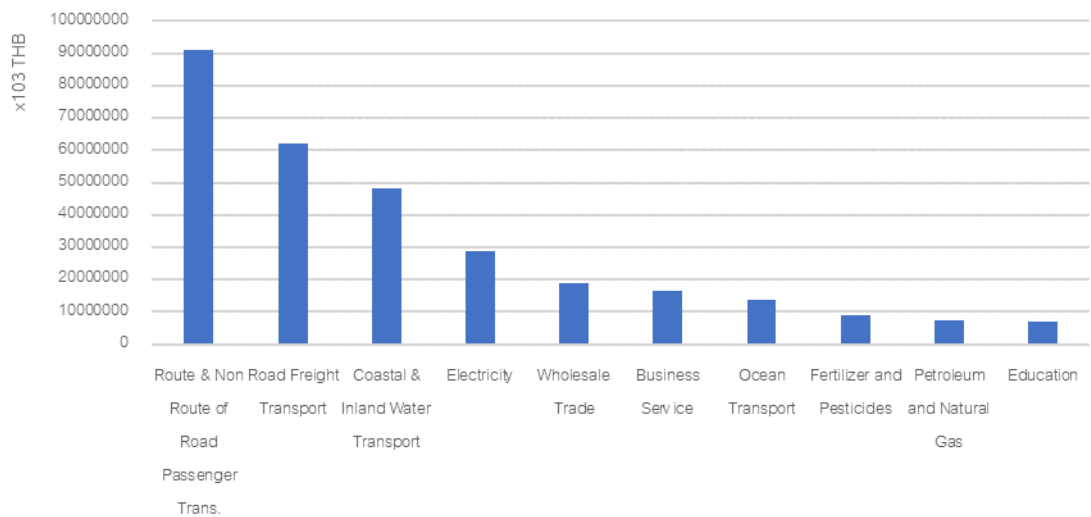
Figure 3-15 Top 10 Industries with highest diesel consumption

3.4 Final Input-Output Table

After we disaggregated into 190 sectors including biofuel and refinery products as mentioned in sector , we combined into 44 sectors to focus on the sectors that are likely to be impacted by the biofuel industry, shown in **Table 3-5**.

Table 3-5 Sector Clarification

190 x 190 Sectors		44 x 44 Sectors	
S001	Paddy	S04	Paddy and Maize
S002	Maize		
S003	Other Cereals		
S004	Cassava	S01	Cassava
S005	Other Root Crops	S04	Beans and Nuts, Vegetables and Fruits
S006	Beans and Nuts		
S007	Vegetables		
S008	Fruits		
S009	Sugarcane	S02	Sugarcane
S010	Coconut	S03	Coconut
S011	Oil Palm	S03	Oil Palm
S012	Kenaf and Jute	S04	Other Crops
S013	Crops for Textile and Matting		
S014	Tobacco		
S015	Coffee and Tea		
S016	Rubber		
S017	Other Agricultural Products		
S018	Cattle and Buffalo	S05	Livestock
S019	Swine		
S020	Other Livestock		
S021	Poultry		
S022	Poultry Products		
S023	Silk Worm		
S024	Agricultural Services		
S025	Logging	S06	Forestry and Fishery
S026	Charcoal and Firewood		
S027	Other Forestry Products		
S028	Ocean and Coastal Fishing		
S029	Inland Fishing		
S030	Coal and Lignite	S07	Crude Oil and Coal
S031	Petroleum and Natural Gas		
S032	Iron Ore	S08	Metal Ore and Non-Metal Ore
S033	Tin Ore		
S034	Tungsten Ore		
S035	Other Non-ferrous Metal Ore		

190 x 190 Sectors		44 x 44 Sectors	
S036	Fluorite		
S037	Chemical Fertilizer Minerals		
S038	Salt Evaporation		
S039	Limestone		
S040	Stone Quarrying		
S041	Other Mining and Quarrying		
S042	Slaughtering	S09	Processing of Foods
S043	Canning Preserving of Meat		
S044	Dairy Products		
S045	Canning of Fruits and Vegetables		
S046	Canning Preserving of Fish		
S047	Coconut and Palm Oil	S10	Coconut and Palm Oil and other Vegetable animal oils
S048	Other Vegetable Animal Oils		
S049	Rice Milling	S09	Rice and Other Grain Milling and other food
S050	Tapioca Milling		
S051	Drying and Grinding of Maize		
S052	Flour and Other Grain Milling		
S053	Bakery Products		
S054	Noodles and Similar Products		
S055	Sugar	S11	Sugar Refineries
S056	Confectionery	S09	Rice and Other Grain Milling and other food
S057	Ice		
S058	Monosodium Glutamate		
S059	Coffee and Tea Processing		
S060	Other Food Products		
S061	Animal Feed		
S062	Distilling Blending Spirits		
S063	Breweries		
S064	Soft Drinks		
S065	Tobacco Processing		
S066	Tobacco Products		
S067	Spinning	S12	Spinning, Weaving and Bleaching and textile product
S068	Weaving		
S069	Textile Bleaching and Finishing		
S070	Made-up Textile Goods		
S071	Knitting		
S072	Wearing Apparels Except Footware		
S073	Carpets and Rugs		
S074	Cordage Rope and Twine Products		
S075	Tanneries Leather Finishing	S13	Leather Products, Saw Mills and Wood Products
S076	Leather Products		
S077	Footwear Except Rubber		
S078	Saws Mills		
S079	Wood and Cork Products		

190 x 190 Sectors		44 x 44 Sectors	
S080	Furniture and Fixtures Wood		
S081	Pulp Paper and Paperboard	S14	Paper and Paper Products, Printing and Publishing
S082	Paper Products		
S083	Printing and Publishing		
S084	Basic Industrial Chemicals	S15	Chemical Products
S085	Synthetic Resins and Plastics		
S086	Fertilizer and Pesticides		
S087	Paints Varnishes and Lacquers		
S088	Drugs and Medicines		
S089	Soap and Cleaning Preparations		
S090	Cosmetics		
S091	Matches		
S092	Other Chemical Products		
S093	Gasoline	S18	Gasoline
S094	GASOHOL95 E10	S19	GASOHOL95 E10
S095	GASOHOL91	S20	GASOHOL91
S096	GASOHOL95 E20	S21	GASOHOL95 E20
S097	GASOHOL95 E85	S22	GASOHOL95 E85
S098	B5 Diesel	S23	B5 Diesel
S099	B10 Diesel	S24	B10 Diesel
S100	Other Refinery Products	S25	Other Refinery Products
S101	Other Petroleum Products	S26	Other Petroleum Products
S102	Rubber Sheets and Block Rubber	S27	Rubber Products and Plastic Wares
S103	Tires and Tubes		
S104	Other Rubber Products		
S105	Plastic Wares		
S106	Ceramic and Earthen Wares	S28	Cement and Concrete Products and non metallic product
S107	Glass and Glass Products		
S108	Structural Clay Products		
S109	Cement		
S110	Concrete and Cement Products		
S111	Other Nonmetallic Products		
S112	Iron and Steel	S29	Iron, Steel, Non-ferrous Metal and Fabricated Metal Products
S113	Secondary Steel Products		
S114	Non-ferrous Metal		
S115	Cutlery and Hand Tools		
S116	Furniture and Fixtures Metal		
S117	Structural Metal Products		
S118	Other Fabricated Metal Products		
S119	Engines and Turbines	S30	Industrial Machinery
S120	Agricultural Machinery		
S121	Wood and Metal Working Machinery		
S122	Special Industrial Machinery		
S123	Office and Household Machinery		

190 x 190 Sectors		44 x 44 Sectors	
S124	Electrical Industrial Machinery	S31	Electrical Machinery and Apparatus
S125	Radio and Television		
S126	Household Electrical Appliances		
S127	Insulated Wire and Cable		
S128	Electric Accumulator & Battery		
S129	Other Electrical Apparatuses & Supplies		
S130	Ship Building	S32	Motor Vehicles and Repairing and Transportation Equipment
S131	Railway Equipment		
S132	Motor Vehicle		
S133	Motorcycle, Bicycle & Other Carriages		
S134	Repairing of Motor Vehicle		
S135	Aircraft		
S136	Scientific Equipments	S33	Other Manufacturing Products
S137	Photographic & Optical Goods		
S138	Watches and Clocks		
S139	Jewelry & Related Articles		
S140	Recreational and Athletic Equipment		
S141	Other Manufacturing Goods		
S142	Electricity	S34	Electricity
S143	Pipe Line	S35	Gas
S144	Water Supply System	S36	Water Works and Supply
S145	Residential Building Construction	S37	Construction
S146	Non-Residential Building Construction		
S147	Public Works for Agriculture & Forestry		
S148	Non-Agricultural Public Works		
S149	Construction of Electric Plant		
S150	Construction of Communication Facilities		
S151	Other Constructions		
S152	Wholesale Trade	S38	Trade
S153	Retail Trade		
S154	Restaurant and Drinking Place	S40	Restaurants and Hotels
S155	Hotel and Lodging Place		
S156	Railways	S39	Transportation and Communication
S157	Route & Non Route of Road Passenger Trans.		
S158	Road Freight Transport		
S159	Land Transport Supporting Services		
S160	Ocean Transport		
S161	Coastal & Inland Water Transport		
S162	Water Transport Services		
S163	Air Transports		
S164	Other Services		
S165	Silo and Warehouse		
S166	Post and Telecommunication		
S167	Banking Services	S42	Business Services

190 x 190 Sectors		44 x 44 Sectors	
S168	Life Insurance Service		
S169	Other Insurance Service		
S170	Real-estate		
S171	Business Service		
S172	Public Administration	S41	Public services
S173	Sanitary and Similar Services		
S174	Education		
S175	Research		
S176	Hospital		
S177	Business and Labor Associations	S43	Personal services
S178	Other Community Services		
S179	Motion Picture Production		
S180	Movie Theater		
S181	Radio, Television and Related Services		
S182	Library and Museum		
S183	Amusement and Recreation		
S184	Repair, Not Elsewhere Classified		
S185	Personal Services		
S186	Unclassified	S44	Unclassified
S187	Molasses Ethanol	S16	Ethanol
S188	Cassava Ethanol		
S189	BioDiesel	S17	BioDiesel

3.5 Scenario Analysis

After the Input-Output table is ready to use after the modification, the next step is to calculate to find the results of the impact on the Thai economy by using the equations mentioned above. The equation that will be used to study backward linkage by using Equation 3-9. To study the coefficients or economic multipliers that measure the effect on the economy. An increase in production by a downstream manufacturer provides positive pecuniary externalities to an upstream manufacturer. The intermediate consumption is, in turn, produced by other branches through the use of new intermediate consumption, and so on. (Eustat, n.d.).

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{L}\mathbf{f} \tag{3-9}$$

Also, to study the impact of biofuel on the Thai economy by using multipliers. We set up three scenarios to compare the effect to Thailand's economy between the different ratios of biofuel used. Assuming the growth of gasoline and diesel demand in Thailand is at 3% or about 6.3 billion THB.

Baseline: The increase in the demand in gasoline and diesel falls into the same current ratio. A mandate for gasoline is at E10 or 10% Ethanol blended and B5 or 5% for biodiesel blended.

Scenario 1: Assume that the government is successful in promoting biofuel by able to decrease conventional Gasoline, E10, and B5 diesel by 20%. The demand falls to E20, E85, and B10 in the same ratio, shown in **Figure 3-11**.

Scenario2: The government launches the new policy with the increment of the biofuel blended mandate. Gasoline and E10 are replaced by E20. and B5 is replaced by B10. That new demand 70% falls to E20, 30% falls to E85.

Scenario3: The increase in the demand falls into E20 and B10

Scenario4: The increase in demand falls into E85 and B10. This sector is unrealistic; however, it's created to show how extremely increase in biofuel products impacts the Thai economy

The comparison between baseline and each scenario shown in **Figure 3-16**.
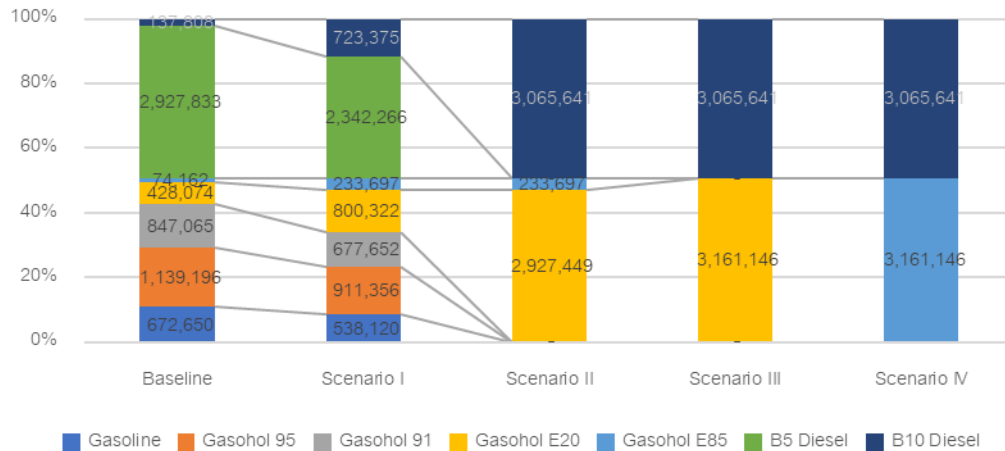
Figure 3-16 Comparison of different ration between Baseline and Scenario I, II and III

Referring to Equation 3-9, the change in final demand ($\mathbf{f}$) or $\Delta\mathbf{f}$ is generated based on each scenario, and after that, we use Leontief inverse to find out the new output of each scenario. Rewrite the equation shown in Equation 3-16. We manage to find delta or the differentiated output of each scenario from this equation.

$$\Delta\mathbf{x} = \mathbf{L}\Delta\mathbf{f} \qquad (3\text{-}16)$$

Derive from Equation 3-16, and Equation 3-17 will be used to study the multiplier effect of labor income specifically. Where is ε labor income coefficient

$$\varepsilon\Delta\mathbf{x} = \Delta\mathbf{W} = \varepsilon\mathbf{L}\Delta\mathbf{f} \qquad (3\text{-}17)$$

Correspondingly, the study of indirect tax coefficient and value-added coefficient will be used Equation

$$\tau\Delta\mathbf{x} = \Delta\mathbf{T} = \tau\mathbf{L}\Delta\mathbf{f} \qquad (3\text{-}18)$$

$$\nu\Delta\mathbf{x} = \Delta\mathbf{V} = \nu\mathbf{L}\Delta\mathbf{f} \qquad (3\text{-}19)$$

Where τ represents the indirect tax coefficient and ν represents the value-added coefficient or the change of GPD.

The change in final demand induces the change in output. This study will focus on the effect of labor income, indirect government tax, and value-added, which represents the country's GDP.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

In chapter 3, we discussed data preparation and calculation formula for the Input-Output table by using Leontief Inverse and multipliers. In this chapter, we'll focus on the result of the calculation. This study has analyzed Thailand's economic impact and sectoral implications of implementing the biofuel promoting in the Thai Government's 10-year alternative energy development plan policy or AEDP plan. The result in this chapter, we'll use the Input-Output sector code by using the abbreviation "S" represents sector and follow by the sector number, as shown in **Table 4-1**. The focused sectors are refinery products, and biofuel products showed in S16 to S24.

Table 4-1 Sector Classification

IO Code	Sector Clarification	IO Code	Sector Clarification
S01	Cassava	S15	Chemical products
S02	Sugarcane	S16	Ethanol
S03	Coconut	S17	Biodiesel
S04	Other Crops	S18	Gasoline
S05	Livestock	S19	Gasohol 95
S06	Forestry and fishery	S20	Gasohol 91
S07	Crude oil and coal	S21	Gasohol E20
S08	Metal ore and non-metal ore	S22	Gasohol E85
S09	Processing of foods	S23	B5 Diesel
S10	Coconut and palm oil and other vegetable animal oils	S24	B10 Diesel
S11	Sugar refineries	S25	Other refinery products
S12	Spinning, weaving and bleaching and textile product	S26	Other petroleum products
S13	Leather products, sawmills, and wood products	S27	Rubber products and plastic wares
S14	Paper and paper products, printing and publishing	S28	Cement and concrete products and nonmetallic product

IO Code	Sector Clarification	IO Code	Sector Clarification
S29	Iron, steel, non-ferrous metal and fabricated metal products	S37	Construction
S30	Industrial machinery	S38	Trade
S31	Electrical machinery and apparatus	S39	Transportation and communication
S32	Motor vehicles and repairing and transportation equipment	S40	Restaurants and hotels
S33	Other manufacturing products	S41	Public services
S34	Electricity	S42	Business services
S35	Gas	S43	Personal services
S36	Waterworks and supply	S44	Unclassified

4.1.1 Backward and forward linkage

A preliminary study by using Leontief Inverse to study the coefficients or economic multipliers that measure the effect on the economy as a result of the initial increase in the production of an economic activity branch. "Backward Linkage" is an increase in production initially requires a higher demand for intermediate consumption for it to be carried out, the intermediate consumption produced by other branches through the use of new intermediate consumption, and so on. The result of backward linkage showed in **Figure 4-1**.
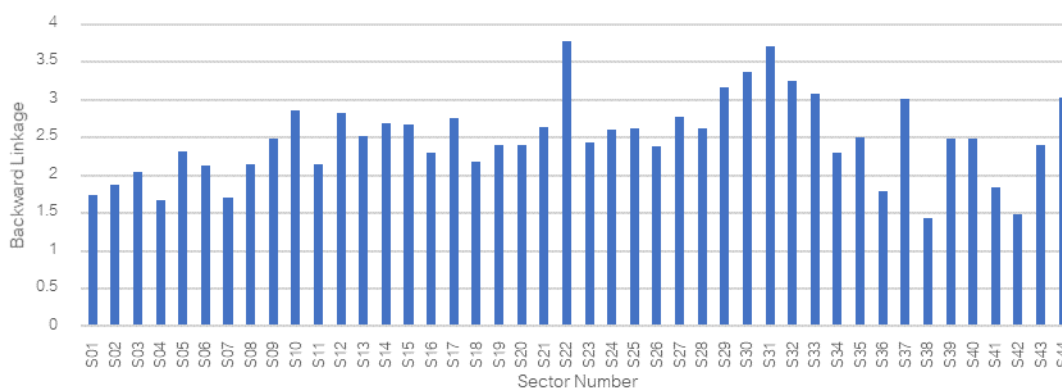
Figure 4-1 Backward Linkage of each industrial sector

As a result, the top 3 industries that have the highest backward linkage are Gasohol E85, Electrical Machinery and Apparatus, and Industrial Machinery. From this result, it can be concluded that Gasohol E85 has a long supply chain, which could be due to the combination of conventional Gasoline and Ethanol, which has a high impact on Thailand's Economy. A higher value of backward linkage represents a robust economic pull of these sectors to the remaining sectors. The backward linkage includes growth through the process of derived demand because the remaining sectors would have to face the losses without the purchase of these sectors. The backward linkage also indicates a measure of the degree of industrialization of these sectors' production. With a lower relative backward linkage indicator, the sector represents little industrialization and technology level. (Tunpaiboon, N 2018)

Another factor that the economist frequently uses to study is "Forward Linkage." The term forward linkage is used to indicate this kind of interconnection of a particular sector with those ("downstream") sectors to which it sells its output.("Ethanol fuel in Brazil," in Wikipedia, 2020). The result of the forward linkage shown in **Figure 4-2**.
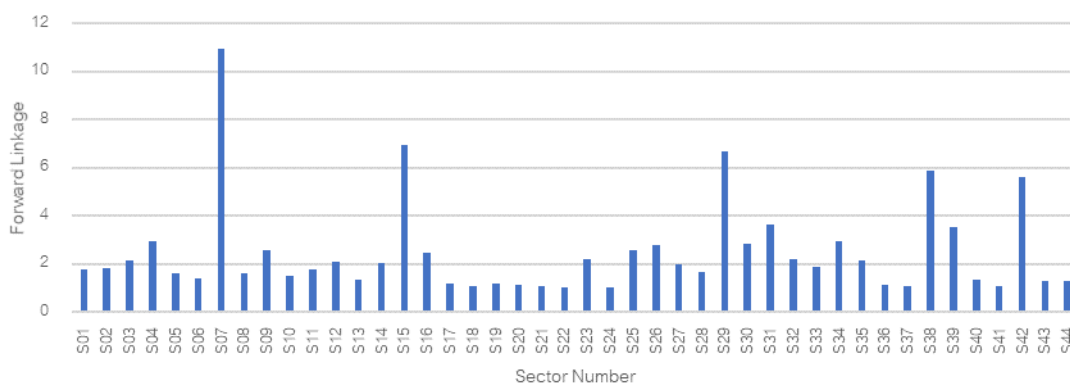
Figure 4-2 Forward Linkage of each industrial sector

Subsequently, three sectors that have the highest forward linkage are Crude Oil and Coal, Chemical Products and Iron, Steel, Non-ferrous Metal and Fabricated Metal Products. Those sectors clearly indicate that the outputs from them will induce attempts to use this output as inputs in some new activities.

4.1.2 Impact of Biofuel industries to Thailand Economy

We set up three scenarios to compare the effect to Thailand's economy between the different ratios of biofuel blended, as mentioned in chapter 3.5. Assuming the growth of gasoline and diesel demand in Thailand is at 3% or about 6.3 billion THB. The scenario was settled up based on the different ratios of biofuel blended into conventional gasoline and diesel. The result can lead to the biofuel mandate policy or AEDP plan guideline

4.1.2.1 Total Output

The output multiplier will generate an estimate of direct + indirect impacts on output throughout the economy. The significant uses of the information in an input-output model are to assess the effect on an economy of changes in elements that are exogenous to the model of that economy. The comparison of output multipliers would show where this spending would have the most significant impact in terms of the total dollar value of output generated throughout the economy. As a result, the total effect for each scenario shows in Table 4-2 The scenario with a higher biofuel blended product used gave the highest impact on the Thai economy. The increase in total output will have a positive impact on the economy. In this case, the scenario II generates the highest total output of +8.94% of the total production to Thailand's economy.

Table 4-2 The result of the total output of each scenario

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S01	Cassava	70,148	117,039	175,817	128,653	766,621
S02	Sugarcane	35,764	59,356	88,956	65,235	386,090
S03	Coconut	62,278	76,003	130,452	130,285	132,538
S04	Other Crops	40,208	43,817	54,716	53,422	70,930
S05	Livestock	15,087	21,101	30,815	25,563	96,602
S06	Forestry and Fishery	6,422	6,812	7,687	7,437	10,818
S07	Crude Oil and Coal	4,898,737	4,823,625	4,877,903	5,007,810	3,250,598
S08	Metal Ore and Non-Metal Ore	14,366	14,985	16,536	16,198	20,773
S09	Processing of Foods	26,958	30,246	36,212	33,581	69,166

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S10	Coconut and Palm Oil and other Vegetable animal oils	40,055	47,900	78,748	78,552	81,193
S11	Sugar Refineries	90,057	149,505	224,089	164,319	972,812
S12	Spinning, Weaving and Bleaching and textile product	15,858	16,692	18,623	18,108	25,073
S13	Leather Products, Saw Mills and Wood Products	5,396	5,622	6,196	6,076	7,699
S14	Paper and Paper Products, Printing and Publishing	44,392	45,446	48,748	48,415	52,923
S15	Chemical Products	428,421	449,017	504,172	494,200	629,089
S16	Ethanol	316,824	530,422	797,962	583,048	3,490,124
S17	BioDiesel	132,701	162,723	282,469	282,343	284,049
S18	Gasoline	684,824	550,323	12,829	13,017	10,477
S19	Gasohol 95	1,159,814	932,023	21,727	22,045	17,743
S20	Gasohol 91	862,396	693,019	16,155	16,392	13,193
S21	Gasohol E20	435,822	808,088	2,935,614	3,169,430	6,667
S22	Gasohol E85	75,505	235,042	235,111	1,435	3,162,302
S23	B5 Diesel	2,984,366	2,403,091	70,247	67,412	105,770
S24	B10 Diesel	140,477	726,247	3,068,959	3,068,825	3,070,644
S25	Other Refinery Products	430,241	429,060	441,854	448,270	361,489
S26	Other Petroleum Products	198,270	196,810	201,387	205,201	153,605
S27	Rubber Products and Plastic Wares	37,116	39,093	43,560	42,300	59,349
S28	Cement and Concrete Products and nonmetallic product	8,779	9,670	11,227	10,492	20,435
S29	Iron, Steel, Non-ferrous Metal and Fabricated Metal Products	149,013	157,250	176,470	171,443	239,441
S30	Industrial Machinery	170,521	177,006	191,271	186,995	244,837
S31	Electrical Machinery and Apparatus	72,977	75,006	80,256	79,207	93,395
S32	Motor Vehicles and Repairing and Transportation Equipment	98,396	99,207	103,870	104,390	97,357
S33	Other Manufacturing Products	45,556	45,692	47,434	47,874	41,923
S34	Electricity	122,176	125,123	134,069	133,029	147,103
S35	Gas	51,196	52,560	56,702	56,220	62,736
S36	Water Works and Supply	3,521	3,857	4,595	4,374	7,366
S37	Construction	6,567	6,881	7,577	7,372	10,147
S38	Trade	299,444	311,937	343,417	336,647	428,232
S39	Transportation and Communication	200,747	215,018	243,705	233,306	373,973
S40	Restaurants and Hotels	22,927	23,444	25,103	24,953	26,976

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S41	Public services	5,767	5,879	6,258	6,234	6,561
S42	Business Services	1,050,226	1,050,093	1,085,059	1,098,059	922,213
S43	Personal services	15,230	16,004	17,656	17,128	24,271
S44	Unclassified	18,216	21,043	25,331	22,759	57,546
	Total	15,593,766	16,008,775	16,987,545	16,738,053	20,112,850
	Percentage Comparison with the baseline		+2.66%	+8.94%	+7.34%	+25.64%

4.1.2.2 The impact on the labor Income

Furthermore, to study the total output, we are more likely to be concerned with the economic impacts of increased household earnings or income rather than merely gross output by sector. The study of the income showed the same trend as total output. The scenario with a higher biofuel blended product used gave the highest impact on the Thai economy showed in **Table 4-3**. Scenario II also generates the highest household income.

Table 4-3 The impact on the labor income of each scenario

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S01	Cassava	17,344	28,938	43,471	31,810	189,550
S02	Sugarcane	10,042	16,667	24,978	18,317	108,410
S03	Coconut	9,060	11,057	18,978	18,954	19,281
S04	Other Crops	7,832	8,535	10,658	10,406	13,816
S05	Livestock	1,267	1,772	2,587	2,146	8,111
S06	Forestry and Fishery	902	956	1,079	1,044	1,519
S07	Crude Oil and Coal	777,758	765,833	774,450	795,075	516,088
S08	Metal Ore and Non-Metal Ore	2,171	2,265	2,499	2,448	3,140
S09	Processing of Foods	1,650	1,851	2,216	2,055	4,233
S10	Coconut and Palm Oil and other Vegetable animal oils	888	1,062	1,746	1,742	1,801
S11	Sugar Refineries	7,095	11,779	17,655	12,946	76,642
S12	Spinning, Weaving and Bleaching and textile product	1,520	1,600	1,785	1,736	2,404
S13	Leather Products, Saw Mills and Wood Products	663	690	761	746	946
S14	Paper and Paper Products, Printing	3,709	3,797	4,073	4,045	4,422

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
	and Publishing					
S15	Chemical Products	38,199	40,035	44,953	44,064	56,091
S16	Ethanol	16,920	28,328	42,616	31,138	186,393
S17	BioDiesel	9,330	11,441	19,860	19,852	19,972
S18	Gasoline	6,860	5,513	129	130	105
S19	Gasohol 95	11,618	9,336	218	221	178
S20	Gasohol 91	8,639	6,942	162	164	132
S21	Gasohol E20	4,366	8,095	29,406	31,748	67
S22	Gasohol E85	756	2,354	2,355	14	31,677
S23	B5 Diesel	29,895	24,072	704	675	1,060
S24	B10 Diesel	1,407	7,275	30,742	30,741	30,759
S25	Other Refinery Products	4,310	4,298	4,426	4,490	3,621
S26	Other Petroleum Products	20,843	20,689	21,170	21,571	16,147
S27	Rubber Products and Plastic Wares	2,393	2,521	2,809	2,727	3,827
S28	Cement and Concrete Products and non-metallic product	744	819	951	889	1,731
S29	Iron, Steel, Non-ferrous Metal and Fabricated Metal Products	10,789	11,386	12,777	12,413	17,336
S30	Industrial Machinery	7,178	7,451	8,052	7,872	10,306
S31	Electrical Machinery and Apparatus	3,368	3,462	3,704	3,656	4,311
S32	Motor Vehicles and Repairing and Transportation Equipment	5,602	5,648	5,914	5,943	5,543
S33	Other Manufacturing Products	4,047	4,059	4,213	4,252	3,724
S34	Electricity	18,417	18,861	20,210	20,053	22,174
S35	Gas	2,024	2,078	2,242	2,223	2,480
S36	Water Works and Supply	794	870	1,037	987	1,662
S37	Construction	485	508	560	544	749
S38	Trade	51,348	53,491	58,889	57,728	73,433
S39	Transportation and Communication	27,130	29,059	32,936	31,531	50,541
S40	Restaurants and Hotels	2,179	2,228	2,386	2,372	2,564
S41	Public services	967	985	1,049	1,045	1,100
S42	Business Services	628,087	628,007	648,919	656,694	551,529
S43	Personal services	3,144	3,303	3,644	3,535	5,010
S44	Unclassified	414	478	575	517	1,306
Total		1,764,153	1,800,394	1,914,544	1,903,260	2,055,889
Percentage Comparison with the baseline			+2.05%	+8.52%	+7.89%	+16.54%

4.1.2.3 The impact on government indirect tax revenue

We also studied the impact on tax, and this can be the guild line for the government to consider the policy implementation. The most challenging part of the biofuel industry for the government is on subsidy spending. However, the government also earn billions of THB each year from gasoline and conventional refinery products. For the study, as we suspected, the scenario with more biofuel product blends generates less tax for the government. The result is shown in **Table 4-4**.

Table 4-4 The impact on government tax of each scenario

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S01	Cassava	0	0	0	0	2
S02	Sugarcane	-1,595	-2,647	-3,967	-2,909	-17,219
S03	Coconut	32	40	68	68	69
S04	Other Crops	0	1	1	1	1
S05	Livestock	6	9	13	10	39
S06	Forestry and Fishery	19	20	23	22	32
S07	Crude Oil and Coal	576,289	567,453	573,838	589,120	382,401
S08	Metal Ore and Non-Metal Ore	270	281	310	304	390
S09	Processing of Foods	2,375	2,665	3,190	2,959	6,094
S10	Coconut and Palm Oil and other Vegetable animal oils	136	163	267	267	276
S11	Sugar Refineries	9,143	15,178	22,749	16,682	98,759
S12	Spinning, Weaving and Bleaching and textile product	174	183	204	199	275
S13	Leather Products, Saw Mills and Wood Products	49	51	57	55	70
S14	Paper and Paper Products, Printing and Publishing	510	522	560	556	608
S15	Chemical Products	4,054	4,248	4,770	4,676	5,952
S16	Ethanol	1,981	3,316	4,989	3,646	21,822
S17	BioDiesel	2,927	3,589	6,231	6,228	6,266
S18	Gasoline	195,408	157,029	3,661	3,714	2,989
S19	Gasohol 95	208,076	167,209	3,898	3,955	3,183
S20	Gasohol 91	155,897	125,278	2,920	2,963	2,385
S21	Gasohol E20	36,857	68,338	248,258	268,032	564
S22	Gasohol E85	-21,055	-65,544	-65,563	-400	-881,835
S23	B5 Diesel	482,391	388,434	11,355	10,896	17,097

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S24	B10 Diesel	13,361	69,076	291,901	291,888	292,061
S25	Other Refinery Products	12,949	12,914	13,299	13,492	10,880
S26	Other Petroleum Products	7,370	7,316	7,486	7,628	5,710
S27	Rubber Products and Plastic Wares	201	212	236	229	321
S28	Cement and Concrete Products and non-metallic product	23	25	30	28	54
S29	Iron, Steel, Non-ferrous Metal and Fabricated Metal Products	426	450	505	490	685
S30	Industrial Machinery	1,699	1,764	1,906	1,863	2,440
S31	Electrical Machinery and Apparatus	1,189	1,222	1,307	1,290	1,521
S32	Motor Vehicles and Repairing and Transportation Equipment	5,666	5,712	5,981	6,011	5,606
S33	Other Manufacturing Products	639	641	665	671	588
S34	Electricity	1,870	1,915	2,052	2,036	2,251
S35	Gas	1,560	1,601	1,728	1,713	1,911
S36	Water Works and Supply	80	88	104	99	167
S37	Construction	72	76	83	81	112
S38	Trade	7,904	8,234	9,065	8,886	11,304
S39	Transportation and Communication	3,695	3,957	4,485	4,294	6,883
S40	Restaurants and Hotels	832	851	911	906	979
S41	Public services	295	301	320	319	336
S42	Business Services	-4,496	-4,496	-4,645	-4,701	-3,948
S43	Personal services	600	630	695	674	955
S44	Unclassified	355	410	493	443	1,121
	Total	1,710,233	1,548,716	1,156,441	1,249,385	-7,841
	Percentage Comparison with the baseline		-9.44%	-32.38%	-26.95%	-100.51%

4.1.2.4 The impact on Value-Added

The value added is a better measure of a sector's contribution to an economy than total output, since it genuinely captures the amount that is added by the sector in engaging in production – the difference between a sector's total output and the cost of its intermediate inputs. Value added is one of the crucial factors that impact the country's GDP. Biofuel sector generated less value-added than the conventional refinery products. As a result, the sector with more biofuel blended gave less value-added showed in **Table 4-5**. This result means the biorefinery sector has a high impact but less value-added coefficient than the refinery products sector.

Another kind of multiplier relates the new value-added created in each sector in response to the initial exogenous shock to that initial shock. The value-added multiplier provides an estimate of the additional value added to the product or service as a result of this economic activity. Value-added includes employee compensation, tax on production and imports, proprietary and other property income.

Table 4-5 The impact on value-added of each scenario

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S01	Cassava	44,866	74,857	112,450	82,285	490,322
S02	Sugarcane	20,811	34,539	51,763	37,960	224,663
S03	Coconut	34,880	42,567	73,062	72,969	74,231
S04	Other Crops	27,699	30,185	37,694	36,802	48,864
S05	Livestock	6,448	9,019	13,170	10,926	41,288
S06	Forestry and Fishery	3,367	3,571	4,030	3,899	5,672
S07	Crude Oil and Coal	3,146,288	3,098,046	3,132,907	3,216,341	2,087,746
S08	Metal Ore and Non-Metal Ore	8,064	8,411	9,282	9,092	11,660
S09	Processing of Foods	7,726	8,668	10,377	9,623	19,821
S10	Coconut and Palm Oil and other Vegetable animal oils	2,636	3,152	5,183	5,170	5,343
S11	Sugar Refineries	38,022	63,120	94,609	69,374	410,716
S12	Spinning, Weaving and Bleaching and textile product	4,569	4,809	5,365	5,217	7,224
S13	Leather Products, Saw Mills and Wood Products	1,888	1,967	2,168	2,126	2,694

Sector Number	Sector Clarification	Baseline	Scenario I	Scenario II	Scenario III	Scenario IV
S14	Paper and Paper Products, Printing and Publishing	12,987	13,295	14,261	14,164	15,483
S15	Chemical Products	131,870	138,209	155,186	152,117	193,636
S16	Ethanol	119,903	200,740	301,991	220,657	1,320,849
S17	BioDiesel	34,694	42,543	73,849	73,816	74,263
S18	Gasoline	224,934	180,756	4,214	4,275	3,441
S19	Gasohol 95	258,080	207,393	4,835	4,905	3,948
S20	Gasohol 91	193,079	155,157	3,617	3,670	2,954
S21	Gasohol E20	55,647	103,179	374,826	404,680	851
S22	Gasohol E85	-17,800	-55,410	-55,426	-338	(745,494)
S23	B5 Diesel	611,061	492,042	14,383	13,803	21,657
S24	B10 Diesel	19,418	100,388	424,218	424,199	424,451
S25	Other Refinery Products	31,499	31,413	32,349	32,819	26,466
S26	Other Petroleum Products	81,032	80,435	82,306	83,865	62,778
S27	Rubber Products and Plastic Wares	7,351	7,743	8,628	8,378	11,755
S28	Cement and Concrete Products and nonmetallic product	2,638	2,905	3,373	3,152	6,140
S29	Iron, Steel, Non-ferrous Metal and Fabricated Metal Products	35,956	37,943	42,581	41,368	57,775
S30	Industrial Machinery	32,148	33,370	36,060	35,253	46,158
S31	Electrical Machinery and Apparatus	12,120	12,457	13,329	13,155	15,511
S32	Motor Vehicles and Repairing and Transportation Equipment	22,985	23,175	24,264	24,385	22,742
S33	Other Manufacturing Products	10,628	10,659	11,066	11,168	9,780
S34	Electricity	50,012	51,219	54,881	54,455	60,216
S35	Gas	10,408	10,685	11,527	11,429	12,754
S36	Water Works and Supply	2,206	2,416	2,879	2,740	4,615
S37	Construction	1,493	1,565	1,723	1,676	2,307
S38	Trade	240,510	250,544	275,829	270,390	343,950
S39	Transportation and Communication	78,096	83,648	94,808	90,763	145,486
S40	Restaurants and Hotels	7,644	7,817	8,370	8,320	8,994
S41	Public services	3,559	3,628	3,862	3,848	4,049
S42	Business Services	834,723	834,617	862,409	872,741	732,978
S43	Personal services	7,065	7,423	8,190	7,945	11,258
S44	Unclassified	3,492	4,034	4,856	4,363	11,032
Total		6,466,701	6,458,901	6,451,304	6,459,948	6,343,026
Percentage Comparison with the baseline			-0.12%	-0.24%	-0.10%	-1.79%

CHAPTER 5

CONCLUSION

5.1 Result and discussion

The studies showed that there will be a positive impact on the Thailand economy through the implementation of the biofuel policy which will increase the labor income and total outputs from the economy. This is attributed to the increase of gasoline and diesel to E20, E85, and B10. However, the indirect tax revenue will decrease hence the reduction of the government sources of income. The most affected sectors are diesel and conventional gasoline because they were replaced by biofuel products as shown in **Figure 4-3** to **4-6**. The findings from this study show that there is an increase in labor income which leads to positive impacts on the households. Therefore, this study has shown that the major benefits of biofuel are to increase labor income and the total outputs.
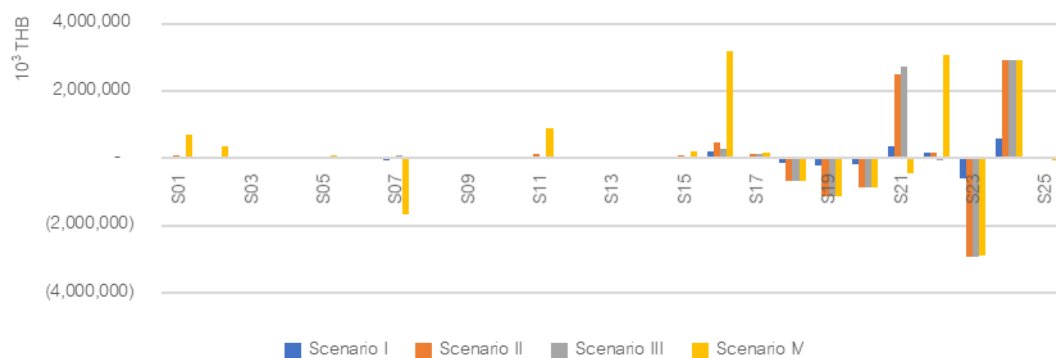
Figure 5-1 The difference between the total output of each scenario and baseline

However, there was a corresponding decrease in conventional fuel which includes crude oil and coal (S07), Gasoline (S18), gasohol 95(S19), gasohol 91 (S20), and B5 Diesel (S23). This is a result of substituting the conventional fuel with biofuels such as biodiesel (S17), Gasohol E20 (S21), gasohol E85 (S22) and B10 diesel (S24), and biofuel feedstock including cassava (S01), sugarcane (S02), sugar refinery (S11)

and Ethanol (S16). The total production in the industry is represented by the total output. Blending different biofuel sectors will lead to a significant increase in the supply chain of corresponding products.
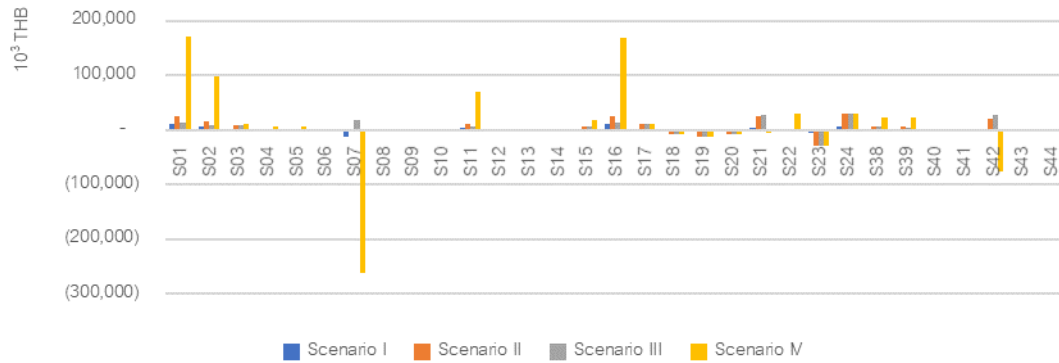
Figure 5-2 The difference between labor income of each scenario and baseline

In scenario (IV), it is evident that biofuel has brought positive impacts to the Thai economy which is extremely high in ethanol-blended. The positive impacts are also felt in some sectors such as high biofuel blended products, sugarcane, and cassava. The crude oil and coal (S07) and fuel feedstock faced a significant decrease that was brought by the biofuel substitutes which also affected the labor income in the conventional fuel sector.
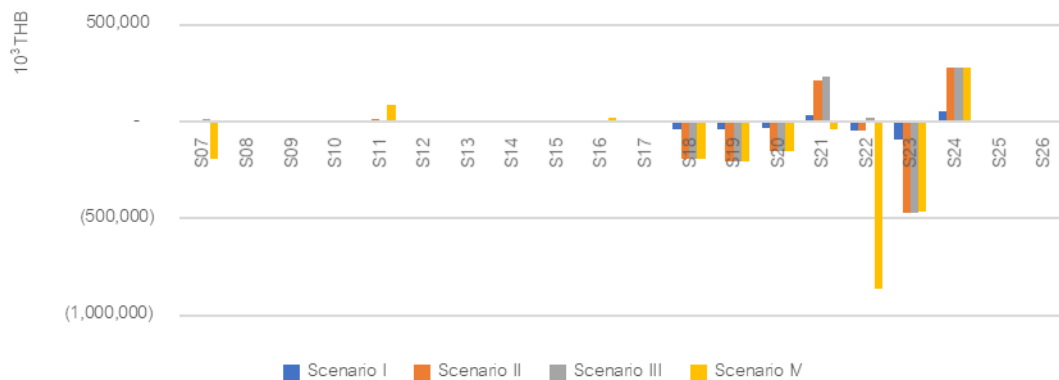
Figure 5-3 The difference between government indirect tax revenue

of each scenario and baseline

The government tax revenue includes the biofuel subsidization from oil funds and refinery products. Consequently, the price competitiveness of biofuels compared to conventional fuels is lower which makes it a limitation. However, the government should subsidize the prices to create a conducive environment in the market that will favor its growth. The study also showed that the government will lose significantly if they are focused on promoting biofuel blended products. Therefore, it is a critical issue for the government because they need to strike a balance between household income revenue and government revenue.
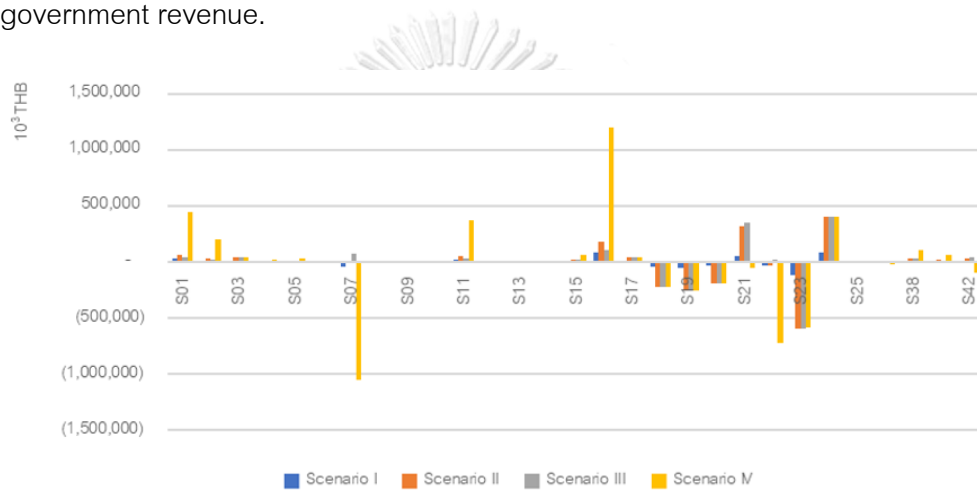
Figure 5-4 The difference between value-added of each scenario and baseline

Value-added is a better measure of a sector's contribution to an economy than say, total output since it truly captures the value that is added by the sector in engaging in production (Barros, 2018). The previous chapter showed that the value-added biofuel products are likely to result low in value or GDP. Therefore, the government should make adjustments in relation to other benefits and examine the best blending ratio of each biofuel product.

5.2 Policy Recommendation

Thailand is a successful country in Southeast Asia in biofuel implementation. By considering Thai transportation fuel regulation the diesel needs to be at least 5% biodiesel blending and gasoline should be at least 10% blended with Ethanol. Therefore, the biofuel industry can survive because of subsidization through retail transportation, fuel price structure and oil fund. This allows it to compete actively in the market. The AEDP also pushes to promote the demand for renewable energy. This targets at least 11 million liters/day and 14 million liters/day on ethanol and biodiesel respectively by 2036. However, the usage is still far from the 2036 prediction because of the unclear way forward on government implementation of policies.

This study will be helpful in the implementation of policies and guidelines. This study aims at comparing the advantages and disadvantages of conventional fuels and biofuels. There are several benefits of using biofuels compared to conventional fuels. Biofuels are environmentally friendly because of fewer gas emissions. Additionally, it increases energy security by reducing the importation of crude oil. However, there have been arguments on using biofuel products or conventional fuel because the government will have to subsidize biofuels because of less price competitiveness, unlike conventional fuel.

The biofuel industry comes with lots of benefits especially on the economy in terms of labor income and total output. However, the government will lose income which will compromise the growth of GDP because of loss from tax revenue. From our comparison, we found out that this income is not completely lost because it is compensated in household income.

Despite the loss from GDP and tax revenue, the money was transferred to household income. If it were possible to eliminate and isolate actions that lower economic welfare and efficiency then reducing the size of government would greatly

benefit the economy. (Lertwitworatep)The government would receive more income from value-added tax from the household and direct tax income from other private companies.

Additionally, another benefit is the CO_2 emission reduction. The use of conventional fuels has greatly led to significant production of CO_2. The government is determined to lower the greenhouse and gas emissions by 20-25 percent by the end of 2030 which is equivalent to 90 million tonnes of carbon dioxide. Transport sector is the main factor that has led to energy demand and a significant increase in gas emissions. In Thailand transport is also one of the leading causes of CO_2 emissions.

Energy reduction and CO_2 mitigation are subjects that many countries and international organization have been focusing on, due to the scarcity of fossil fuels and dramatic increase in oil prices as well as environmental concern ((" EU-Japan Centre for Industrial Cooperation," 2012). Therefore, promoting biofuel implementation is a great opportunity for the government to meet the essential target, especially when biofuel products are net-zero emission.

5.3 Limitations of the study

The study also assumed that the supply of biofuel is adequate. Here are some other topics that need additional research and study.

1. Feedstock availability

This involves irrigation and land mobilization because the demand for biofuel will consequently affect feedstock availability. The feedstock availability requires all the stakeholders to come on board and restructure the production of feedstock that will also influence the growth of biofuels.

2. Feedstock price

The main challenge in the biofuel industry is the pricing which is attributed to an increase in the price of feedstock. The increase in the demand for biofuels has affected the feedstock prices and other foods including the factory profit or loss.

3. Type of feedstock

According to the current regulation, only cassava and sugarcane can be used as sources of biofuel feedstock, while the others have been designated for human consumption only. Therefore, there is a need to do more study on agricultural products that requires less cost, water, and land so that it can subsidize the pricing of biofuel.

4. Crude oil price

This study utilizes the average pricing of the year 2016 but in recent years there's been lots of fluctuation at the price of crude oil. Then, the figures from the average price in 2016 might not represent the current situation since the crude oil prices tend to change depending on fluctuations and economic growth.

5. Technology disruption

This study only focuses on the use of liquid fuel as the main source of energy since it did not include the plans of using electric vehicles which will bring a significant impact on biofuels and conventional fuels. Therefore, if there will be a shift to electric transport systems then the biofuel industry will be compromised significantly which should have been also captured by the study to speculate future trends.

The government should step out as a major player in supporting the industry by reducing production costs and increasing price competitiveness so that it can grow and becomes sustainable. This can be achieved by using low-cost production on feedstocks, GMO feedstocks, value-added products that lead to an improvement in production using the latest innovation and technologies. The government will also benefit because biofield plants require less input and it can be outsourced from the locals leading to fewer subsidy.

Therefore, this study will also serve as an instrumental reference to the research and studies that will be done in the future concerning their impacts that biofuels bring to the economy.

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APPENDICES

Appendix A

40 x 40 Input-Output Table showed in **Table A-1**, sector clarification showed in **Table 4-1** and **Table A-1**, the table will be divided into several pages due to limited space. Each section of the table represents in a different color; the table guideline showed in **Figure A-1**.

Figure A-1 Table color guideline

Table A-1 Sector Clarification

IO Code	Sector Clarification	IO Code	Sector Clarification
190	Total Intermediate Transaction	304	Increase in Stock
201	Wages and Salaries	305	Exports (F.O.B.)
202	Operating Surplus	306	Special Exports
203	Depreciation	309	Total Final Demand
204	Indirect Taxes less Subsidies	310	NEW Total Demand
209	Total Value Added	401	Imports (C.I.F.)
210	Control Total	402	Import Duty
190	New Total Intermediate Transaction	403	Import Tax
301	Private Consumption Expenditure	404	Special Imports
302	Government Consumption Expenditure	409	Total Imports
303	Gross Fixed Capital Formation	600	Control Total

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23
S01	5,738,586			3,701	12,476				35,041,609	31,114,099	50,778,652					5,812,848							
S02		4,206,206			11				41,980	21,012,920	128,506					103,876							
S03			802,863	158,718					1,448,579		51,473						9,950,417						
S04		2,737,227	7,439						474,748,631			88,371	84,168	5,382	1,727	298,535	359,342						
S05	1,201,940		726,686		10,593,932	1,142,666			174,691,088			382,117			44,920	574	273						
S06				66,296,108	20,591,714	7,796,994			68,229,813			3,601,881	1,610,583	817,127	6,863,881								
S07				21,918,355	4,163,102		459	167,160	369,924	287		77,695		3,112,867	1,755,255			41,389,114	73,206,872	54,322,412	27,055,281	905,184	434,144,841
S08			65		125,705	16,467	15,939,683	82,355	1,434,884	745,916	4,126	52,311	50,715	385,746	5,054,306			27	47	35	17	1	279
S09				33,667		17,464,795	178,386		274,000,511	4,050,747	933,876	44,817		195,851	7,707,430								
S10				68,750					38,312,795		221	427,667		881,043	4,762,178								
S11									54,572,740		911,445	221			7,862,185			5,929	10,488	7,782	3,876	130	62,196
S12	1,221		13,896	1,060,406		785,561	880	40,210	1,297,003	7,693	150,467	297,487,721	238,479	1,172,732	1,347,706	8,489,367	6,557,361						
S13	466		18,588	1,871,790		122,321		204,524	1,774,436	4,675	6,124	828,221	6,749,541	224,354	8,851,940			2,085	3,688	2,736	1,363	46	21,869
S14				471,727		21,868	152,660	104,234	8,415,663	276,314	29,554	4,244,194	46,169,660	149,443	1,278,048	43,919	52,864	6,508	11,511	8,542	4,254	142	68,267
S15	3,090,461	3,870,170	8,950,365	110,184,857		1,204,511	536,733	3,201,016	20,120,359	1,315,420	1,152,755	60,155,889	2,023,969	81,556,880	5,173,236	691,848	1,001,453	1,422,335	2,515,751	1,866,788	929,754	31,107	14,919,371
S16													18,570,047	21,616,361	302,780,860								
S17															8,083,779			8,381,836	8,574,880	6,381,836	7,725,173		24,597,711
S18	24,405	104,605		984,514	596,945	3,788,546	1,730	34,096	34,702			32,068	25,497	124,437	43,996	12,468		164,218	290,460	215,533	107,346	3,591	
S19	41,333	177,158		1,667,367	1,010,982	6,416,261	2,931	57,744	58,771			54,311	43,182	210,746	74,511	21,116		278,119	491,922	365,026	181,801	6,082	
S20	30,733	131,728		1,239,794	751,730	4,770,899	2,179	42,936	43,700			40,383	16,227	156,703	55,404	15,701		206,799	365,775	271,420	135,181	4,523	
S21	15,532	66,571		626,545	379,896	2,411,032	1,101	21,698	22,084			20,408	340,005	79,192	27,999	7,935		104,508	184,849	137,165	68,315	2,286	
S22	2,691	11,533		108,547	65,816	417,703	191	3,759	3,826			3,536	16,158	13,720	4,851	1,375		18,106	32,024	23,763	11,835	396	
S23	572,284	1,248,003	1,672,224	20,058,272		10,090,743	34,597	2,203,071	1,596,807		3,313	99,424		64,748	7,802,040								
S24	27,197	59,309	79,469	953,229	108,829	479,542	1,644	104,696	75,885	147,043	157	4,725		3,077	370,776								
S25	13,942	4,505	76,680	604,812	2,883,867	88,821	27,198,096	1,650,921	8,754,913	15,343	619,614	4,965,008	675,736	974,624	28,500,612	381,143	215,372	3,861	6,829	5,067	2,524	84	1,947,522
S26	30,812	460,626	58,789	1,346,420	997,834	2,171,192	6,632,498	1,693,023	785,078	834,635	95,452	931,986	334,774	281,376	2,351,404								40,496
S27	15,543	2,816	75,373	6,991,759	650,018	1,883,747	280,112	520,963	14,839,491		1,240,469	8,922,096	11,240,749	3,199,904	10,152,171	28,097	33,819	19,876	35,155	26,087	12,992	435	208,484
S28			63,387	649,944	27,879	231,877	156	19,861	7,953,955	395	1,057,711	34,155	582,905	36,729	2,788,110								
S29	573,342	404,805	1,822,931	9,472,207	1,010,291	1,242,610	17,017	1,838,509	35,961,322		830,882	2,264,497	6,735,365	2,150,802	5,038,949	46,132	55,528	16,467	29,127	21,613	10,764	360	172,733
S30	46,709	568,588	94,858	4,407,060	1,132,331	1,261,057	6,005,148	2,574,537	8,424,788	231,712	2,320,157	4,977,455	2,762,223	3,211,580	8,499,336	527,700	143,418	29,679	52,494	38,953	19,400	649	311,310
S31				334,405	161,259	94,886	356,291	112,575	63,275	176,740	10,379	16,450	35,069	689	51,836								
S32	1,728	22,181	12,914	2,815,461	896,730	3,038,823	3,538,468	5,385,301	3,258,882	50,837	186,046	714,020	747,661	321,793	1,766,456			16,874	29,845	22,146	11,030	369	176,994
S33				158,402	213,087	53,612	948,654	105,337	737,827	22,139	20,265	14,132,171	5,154,874	1,182,335	1,728,364			5,087	8,997	6,676	3,325	111	53,358
S34	9,510	140,087	21,557	2,090,104	2,795,842	395,875	3,061,767	1,829,580	44,932,538	980,743	2,242,488	41,848,758	6,783,773	5,402,532	19,659,181	99,720	120,031	142,293	251,680	186,757	93,014	3,112	1,499,560
S35				65,151	4,201	9,324	5,054	318,282	2,275,903	120,106	245,279	1,016,869	119,837	361,371	21,709,363			64,332	113,787	64,434	42,053	1,407	674,800
S36		33,720		300,978	131,021	259,099	161,916	103,870	2,790,197	487,505	103,106	881,179	189,463	457,739	1,758,599	16,374	19,710	1,027	1,816	1,348	671	22	10,772
S37	1,122	712		243,252	731,993			162,359	924,777	22,723	274,318	720,939	288,735	339,150	1,102,830	15,924	19,167	1,007	1,781	1,321	658	22	10,561
S38	1,332,518	5,017,614	3,746,220	63,020,686	15,960,875	6,967,129	6,680,105	2,612,697	118,922,880	3,073,009	5,610,809	58,080,598	29,394,041	30,570,680	69,945,903	245,183	295,123	300,598	531,682	394,530	196,495	6,574	3,153,081
S39	485,243	1,521,330	911,968	14,216,931	2,411,965	1,467,911	5,998,765	4,020,991	36,412,577	1,765,980	4,630,384	12,916,486	8,539,910	8,029,980	24,169,537	1,114,444	892,633	186,890	330,561	245,289	122,166	4,087	1,960,353
S40				2,849,426	116,744	425,425	528,729		1,857,642	45,776	74,727	957,783	1,440,714	942,310	2,063,553	11,226	13,513	9,760	17,263	12,810	6,380	213	102,379
S41				14,765	23,584		28,320	8,621	1,758,805	16,677	34,164	546,600	92,852	436,889	1,751,492			7,913	13,996	10,386	5,173	173	83,002
S42	1,731,100	1,739,939	905,111	28,773,978	5,039,979	2,475,805	65,727,731	1,838,080	48,686,539	1,104,299	5,055,358	23,180,379	10,235,371	10,756,570	32,350,296	745,152	315,096	227,207	401,872	298,205	148,521	4,969	2,383,254
S43		563,335	1,037	353,290	76,470	201,023	292,728	72,051	2,275,151	32,888	162,778	816,766	381,346	243,759	1,627,625	36,699	47,212	16,065	28,416	21,086	10,502	351	168,515
S44	125	996	55,923	852,909	556,489	288,893	296,565	31,517	11,205,686	106,095	83,957	3,847,289	1,084,734	1,553,021	3,990,197	354,947	13,838	11,621	20,554	15,252	7,596	254	121,893
190	14,988,542	23,093,765	20,118,344	367,393,993	169,571,908	79,490,293	144,611,295	31,600,523	1,508,547,912	67,764,131	79,058,270	549,417,222	192,049,678	181,224,238	609,922,177	19,122,302	20,106,171	44,658,305	87,564,123	64,994,998	36,917,463	9,060,460	486,886,599
201	10,282,622	15,509,110	6,652,812	230,025,217	24,665,690	23,461,478	64,180,237	10,887,123	129,418,700	1,608,726	10,779,671	73,988,590		21,401,807	78,563,992	1,643,065	1,914,091	666,141	1,128,173	838,869	423,932	73,445	6,132,897
202	15,604,857	18,646,230	18,671,408	554,155,659	95,960,952	55,782,391	100,275,597	24,330,101	248,146,933	2,538,319	24,842,078	106,244,658	51,328,720	40,180,375	147,264,828	7,812,354	4,121,149	1,375,991	2,330,370	1,732,779	875,681	151,709	12,668,200
203	711,160	448,341	264,238	29,352,895	5,625,813	7,858,672	47,615,243	3,861,772	42,107,088	379,511	8,254,625	33,634,696	13,071,303	10,416,012	37,052,994	1,995,583	481,675	825,019	1,397,247	1,038,942	525,042	90,962	7,595,621
204	116	(2,463,398)	23,846	14,351	120,933	501,472	47,555,090	1,430,843	186,280,658	246,295	13,890,404	8,471,879	2,698,364	2,944,483	8,337,018	192,363	600,495	18,975,342	20,205,465	15,138,566	5,579,004	(2,044,588)	98,963,132
209	26,598,755	32,140,284	25,612,305	813,548,122	126,573,388	87,604,013	259,630,167	40,430,843	605,962,378	4,773,851	57,766,778	222,339,823	103,384,555	74,942,677	271,218,832	11,643,366	7,117,410	21,842,493	25,061,255	18,749,156	5,403,659	(1,728,473)	125,359,650
210	41,587,297	55,234,049	45,730,649	1,180,942,115	296,145,296	167,084,306	404,241,462	72,031,366	2,114,510,290	72,537,982	136,825,048	771,757,045	295,434,233	256,166,915	881,141,009	30,785,668	27,223,581	66,500,798	112,625,378	83,744,154	42,321,122	7,331,988	612,246,449

Table A-2 Input-Output Table 40x40

	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40	S41	S42	S43	S44	190
S01	20,856,120	-	-	-	-	-	-	-	11,724	-	-	-	-	-	6,713	-	791,101	-	-	-	2,002,904	49,403,224
S02	-	-	-	-	-	-	-	-	-	569,136	15,742	-	-	312,716	-	-	24,753	-	44,500	1,112	180,603	55,399,150
S03	-	-	-	-	-	-	-	-	-	41,027	228,137	-	-	-	-	-	446,502	-	14,093	-	24,026	44,226,487
S04	-	-	-	155,971,499	84	-	-	-	51,140	237,715	-	-	-	-	-	2,267,473	63,211,998	2,606,762	12,823,045	2,569,721	8,358,578	829,795,381
S05	-	-	-	-	-	-	-	-	-	8,735	156,868	-	-	4,423,019	-	42,367	3,445,594	529	545,910	80,576	472,088	235,220,467
S06	-	-	40	576,128	762,169	80,685	33,308	492,148	1,356,872	15,538,201	120,967,952	229,167,174	30,968	38,710,034	4,571,543	-	21,114,815	-	1,305,848	68,006	315,337	139,367,257
S07	13	223,456,698	787	200,507	8,348,021	5,760,799	656,685	44,309	6,098	2,981,871	24,007	-	-	-	-	21,063	446	-	12,606	2,809	200,314	1,263,628,077
S08	-	144	-	904,805	54,045,914	22,742,071	-	-	-	-	482,156	-	-	-	-	6,563,710	4,639	943,183	9,814,225	4,383,668	2,252,028	145,925,264
S09	-	-	133,400	123,943	1,127,797	-	-	-	-	-	-	-	-	-	-	-	184,328,434	-	806,798	1,902,076	21,045,694	631,762,973
S10	2,988	32,013	-	246,032	-	-	-	-	-	-	753,710	-	-	-	-	39,280	16,752,047	-	425,966	39,321	1,758,594	79,688,550
S11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,941,495	-	-	-	369,871	70,548,143
S12	1,051	11,256	7,974	6,440,300	767,058	265,986	557,324	3,129,605	2,987,450	10,397,879	164,203	9,562	20,126	472,844	10,356,499	3,287,765	8,811,302	5,511,497	1,788,985	3,724,167	7,992,587	383,393,585
S13	3,279	35,137	1,721	503,754	666,968	2,018,863	1,989,110	2,111,530	5,093,246	5,338,039	55,519	-	1,321	17,213,457	12,074,647	1,264,644	439,421	2,147,889	510,368	2,449,058	2,078,375	107,967,222
S14	716,720	7,679,081	29,996	1,633,803	2,624,027	1,732,126	5,381,573	3,249,872	7,604,118	4,778,047	563,326	156,603	51,155	826,524	12,043,906	4,697,200	2,588,580	2,147,889	29,671,301	3,554,552	4,482,583	266,570,901
S15	-	-	2,247,976	193,955,178	31,984,446	14,787,387	44,109,095	24,631,352	42,903,186	22,948,737	1,372,965	60,440	1,995,387	17,615,928	3,224,623	2,569,363	9,537,035	7,720,757	63,938,628	44,370,973	9,132,964	1,131,665,918
S16	2,625,870	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30,765,668
S17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27,223,581
S18	-	-	18,183	43,060	28,516	107,636	573,472	69,292	2,418,424	61,028	-	-	40,886	491,292	-	20,106,009	224,167	1,671,253	1,407,324	6,064	92,724	33,907,605
S19	-	-	30,795	72,925	48,295	182,292	971,230	117,353	4,095,829	103,356	-	-	1,943	832,050	-	34,051,425	379,649	2,830,424	2,383,436	10,270	157,038	57,425,729
S20	-	-	11,572	54,225	35,911	135,546	722,171	87,259	3,045,510	76,852	-	-	114,807	618,682	-	25,319,406	282,293	2,104,601	1,772,237	7,637	116,767	42,699,693
S21	-	-	-	27,403	18,148	68,500	364,958	44,098	1,539,085	38,838	-	-	14,375	312,659	-	12,795,469	142,660	1,063,586	895,621	3,859	59,010	21,578,807
S22	-	2,005	2,005	4,747	3,144	11,867	63,228	7,640	266,641	6,729	-	-	381,681	54,167	-	2,216,771	24,715	184,263	155,163	669	10,223	3,738,453
S23	-	-	545	143,337	2,449,180	319,037	8,382,483	84,155	7,548,316	150,149	32,052,787	1,514,484	145,477	9,577,703	27,194,533	231,782,667	2,801,632	16,583,276	13,540,617	8,320,736	667,783	409,715,380
S24	93,558	1,002,400	2,306,636	6,812	116,392	15,162	398,361	3,999	358,718	7,136	7,136	2,242,278	1,943	455,161	1,060,490	11,061,062	133,142	802,767	644,439	379,327	31,735	19,284,609
S25	1,945	20,844	56,465,644	5,553,312	8,730,630	10,109,243	4,786,499	2,634,824	1,949,273	3,328,165	18,996,965	784,811	114,807	1,091,635	758,868	46,695,217	5,092,101	2,295,668	734,592	4,054,144	-	200,716,578
S26	71,702	107,308	164,038	1,027,243	2,154,258	1,142,853	5,507,425	1,576,732	16,272,640	781,842	63,968	3,837	14,375	5,402,515	1,412,916	25,977,764	592,214	2,063,774	388,312	86,478	1,156,642	140,359,689
S27	-	-	24	48,530,895	1,586,022	6,098,380	56,449,321	15,603,770	58,876,806	15,603,506	312,113	-	381,681	11,447,759	41,851,976	15,899,525	3,157,133	5,199,912	2,045,993	3,795,567	9,180,403	364,531,914
S28	8,298	88,906	68,761	73,483	48,141,312	2,178,942	8,798,492	14,131,550	8,444,559	10,604,637	-	-	468,316	198,353,637	198,353,637	24,020	2,019,909	378,416	321,190	96,785	6,462,599	315,054,064
S29	14,955	160,233	186,903	4,747,619	24,755,275	322,261,031	364,762,484	108,144,550	227,120,344	185,376,009	730,185	1,514,484	145,477	136,500,180	58,311,095	5,197,620	1,731,799	2,455,343	1,984,873	22,933,625	7,354,407	1,484,867,609
S30	-	-	-	5,241,755	4,772,009	4,362,845	827,503,603	7,671,820	115,940,502	7,614,092	4,480,750	2,242,278	133,178	7,614,092	-	8,191,193	1,660,805	10,893,057	3,451,848	18,517,493	6,816,412	1,082,109,806
S31	-	91,100	20,354	16,739	231,664	356,643	272,390,502	596,392,134	71,278,678	3,091,242	14,460,273	-	21,078	52,462,289	7,676,321	5,076,730	9,582,195	5,471,234	1,111,734	31,180,354	7,924,326	1,079,961,250
S32	8,503	91,100	11,210	1,155,219	1,274,132	1,281,240	9,549,148	1,245,758	364,519,561	2,184,852	1,196,226	134,096	49,147	5,158,990	8,230,603	125,853,604	805,042	7,806,842	4,287,652	2,579,419	462,794	560,908,839
S33	2,563	27,464	11,210	1,329,909	509,567	756,058	15,909,939	3,459,223	272,278,938	272,278,938	283,719	165,333	451,914	773,685	2,606,781	1,650,522	988,729	6,798,784	21,403,867	11,190,497	9,223,768	377,343,006
S34	32,417	347,323	347,154	28,514,369	5,232,416	20,372,878	43,135,249	14,000,566	283,719	15,603,506	312,113	3,894,714	8,990,240	6,188,872	58,311,095	23,730,276	64,057,303	33,983,377	25,841,067	20,708,982	1,644,265	251,164,451
S35	517	5,544	30,537	1,188,271	5,232,416	1,934,082	3,605,819	1,137,249	1,825,083	1,574,841	134,504,131	57,896,425	-	414,757	67,077	1,825,322	8,192,512	1,495,119	975,288	341,964	1,317,320	579,955,132
S36	507	5,436	30,343	756,385	532,327	292,697	1,920,697	860,760	1,386,014	1,538,991	1,047,196	281,253	1,842,037	319,854	3,364,972	1,225,539	3,029,497	3,136,383	726,477	1,233,848	25,383	28,919,999
S37	151,473	1,622,908	5,014,463	776,530	737,955	499,236	3,417,215	849,270	1,281,352	104,284,557	15,105,197	2,227,131	578,715	890,578	1,344,635	1,260,312	3,126,248	11,061,100	2,502,643	4,274,810	229,361	40,077,383
S38	94,174	1,009,004	492,095	59,616,966	20,241,658	25,322,138	362,492,197	87,670,967	90,926,424	18,564,913	6,430,058	2,043,901	321,594	75,743,544	17,882,116	52,278,834	59,011,960	10,903,468	50,927,678	29,144,627	17,060,552	1,534,245,515
S39	4,918	52,695	56,862	19,933,172	17,733,011	10,156,167	45,601,540	22,661,747	21,070,598	2,649,860	946,590	1,169,642	43,678	4,892,869	80,348,306	209,121,488	22,723,529	73,137,530	13,073,946	22,138,873	5,805,525	807,569,999
S40	3,987	42,721	15,937	1,381,903	755,571	905,129	3,198,102	1,581,631	3,078,457	1,142,767	471,747	934,990	360,591	620,483	64,639,994	2,524,321	2,047,037	14,892,856	4,530,871	4,059,147	1,379,248	136,702,664
S41	114,490	1,226,674	285,593	17,067,243	1,114,627	354,051	1,806,068	1,050,985	3,078,457	24,961,182	31,566,505	919,847	19,937	2,620,890	246,291	2,620,890	2,667,142	7,076,923	3,447,370	951,929	1,523,208	32,502,683
S42	3,987	86,736	66,956	433,766	22,437,474	14,192,218	33,796,995	15,770,379	34,231,424	24,961,182	31,566,505	15,702,366	5,357,518	32,016,150	185,787,888	113,174,566	40,095,562	189,989,184	15,801,659	18,439,958	10,089,568	1,066,138,405
S43	8,095	62,739	64,871	676,250	578,860	730,672	9,943,062	2,344,782	2,207,122	1,901,056	1,038,451	919,847	19,937	1,278,994	2,084,056	5,372,619	5,096,359	90,205,868	4,850,183	34,621,824	2,918,521	174,377,344
S44	5,856	62,739	64,871	570,257	4,318,513	920,779	624,006	1,477,841	8,812,918	1,670,378	1,122,440	1,458,116	399,028	1,161,302	28,528,006	5,830,441	1,135,051	3,538,280	1,324,943	2,765,105	1,126,922	91,418,046
190	24,834,017	237,942,591	68,183,746	559,499,723	279,528,970	472,455,350	2,139,401,362	941,363,150	1,140,156,945	731,757,759	416,843,597	321,064,573	21,850,026	706,976,073	578,122,074	1,021,676,473	624,975,491	1,671,253	302,233,336	304,990,032	173,503,052	16,429,769,500
201	288,665	2,571,766	12,121,781	44,984,211	33,843,359	45,086,687	110,980,424	52,103,682	84,701,948	84,777,915	106,382,370	15,932,729	13,198,134	67,580,245	503,707,371	225,994,793	79,028,424	273,612,807	880,864,688	117,416,822	4,873,284	3,510,794,662
202	596,271	5,312,278	24,198,438	65,714,711	62,210,158	86,542,860	274,030,580	76,773,397	100,394,896	90,877,954	90,877,954	24,249,673	13,155,928	86,724,333	1,566,227,278	262,738,851	130,464,126	441,410,084	92,428,084	98,016,513	14,605,659	5,188,130,368
203	357,513	3,185,144	6,520,033	23,713,443	22,947,204	16,845,400	85,756,632	40,218,883	40,734,713	24,113,159	80,828,330	29,464,275	8,971,196	43,703,190	211,833,192	131,030,049	37,555,381	208,976,761	203,675,833	26,030,288	7,489,854	1,518,558,928
204	2,740,938	7,727,373	4,286,503	3,779,071	1,052,702	1,790,531	26,270,170	18,387,347	85,658,321	13,379,889	10,800,716	12,277,633	1,328,589	10,060,544	77,539,508	30,777,620	30,181,084	83,563,699	(6,305,615)	22,393,235	4,180,882	867,452,877
205	3,983,387	18,796,561	47,126,755	138,191,436	120,053,423	150,255,478	497,037,806	187,483,309	347,520,961	222,655,859	288,889,370	81,924,310	36,653,847	208,068,312	2,359,307,349	650,541,313	277,229,015	1,007,563,331	1,170,662,990	263,856,858	41,149,679	11,084,926,835
210	28,817,403	256,739,153	115,310,501	697,691,159	399,582,393	622,710,828	2,636,439,168	1,128,846,459	1,487,677,906	954,413,618	705,732,967	402,988,883	58,503,873	915,044,385	2,937,429,423	1,672,217,786	831,474,462	1,632,538,822	1,472,896,326	568,846,890	214,652,731	27,514,693,335

Table A-2 Input-Output Table 40x40 (Continue)

	301	302	303	304	305	306	309	310	401	402	403	404	409	600
S01	736,876	354		(8,321,338)	9,902		(7,574,206)	41,829,018	(100,953)	(25,310)	(2,462)		(128,725)	41,700,293
S02	4,717	-			7,516		12,233	55,411,383	(8,365)				(8,365)	55,403,018
S03	180,068	390			1,756,032		1,936,490	46,162,977	(78,261)	(8,885)	(1,711)	(2)	(88,859)	46,074,118
S04	262,480,064	3,590,859	1,461,943	50,526,408	130,768,739	8,692,716	456,058,786	1,285,854,167	(93,981,807)	(2,298,195)	(1,856,478)	(6,775,572)	(104,912,052)	1,180,942,115
S05	58,588,134	451,244			3,339,547	515	63,841,383	299,061,850	(2,824,439)	(24,957)	(67,019)	(139)	(2,916,554)	296,145,296
S06	40,256,349	103,381	62,723	(14,324,859)	8,920,777	2,597	35,020,968	174,388,225	(6,753,377)	(163,485)	(376,831)	(226)	(7,293,919)	167,094,306
S07	-	-		24,801,986	42,910,608		67,712,594	1,331,340,671	(916,438,094)	(168,991)	(64,869,536)		(981,476,621)	349,864,050
S08	-	-		(71,799,441)	18,136,784		(53,662,657)	92,262,607	(19,031,330)	(174,912)	(1,025,033)		(20,231,275)	72,031,332
S09	927,047,823	11,187,852		98,751,406	666,186,668	12,302,472	1,715,476,221	2,347,239,194	(165,259,608)	(7,630,826)	(20,174,737)	(15,573,671)	(208,638,842)	2,138,600,352
S10	31,805,412	6,560		22,610,812	10,724,901	374	65,148,059	144,836,609	(44,162,857)	(755,050)	(506,088)	(2,164)	(45,426,159)	99,410,450
S11	6,600,176	4,297		4,548,619	67,538,428	182	78,691,702	149,239,845	(5,197,353)	(399,680)	(423,347)	(776)	(6,021,156)	143,218,689
S12	241,205,939	2,987,331	5,195,439	(13,882,059)	234,019,709	68,180,523	537,706,882	537,706,882	(126,743,682)	(2,119,094)	(5,253,092)	(15,227,554)	(149,343,422)	771,757,045
S13	70,947,698	4,502,489	34,624,369	23,761,805	94,119,428	5,850,918	233,806,707	233,806,707	(42,803,440)	(1,070,931)	(1,902,497)	(565,471)	(46,342,339)	295,431,590
S14	45,016,123	25,277,611		(9,814,294)	42,843,231	10,811,853	114,134,524	380,705,425	(78,744,474)	(1,815,186)	(4,496,324)	(39,490,774)	(124,546,758)	256,158,667
S15	111,138,881	6,440,147		(116,227,975)	440,219,781	27,071	441,597,905	1,573,263,823	(651,275,799)	(12,610,589)	(25,408,398)	(4,672,361)	(693,967,147)	879,296,676
S16								30,765,668						30,765,668
S17								27,223,581						27,223,581
S18	18,497,559	3,924,094		1,521,949	9,273,102	17,298	33,234,001	67,141,606	(389,920)	(2,737)	(242,403)	(5,748)	(640,808)	66,500,798
S19	31,327,362	6,645,824		2,577,564	15,704,873	29,295	56,284,918	56,284,918	(660,367)	(4,635)	(410,532)	(9,735)	(1,085,269)	112,625,378
S20	23,293,892	4,941,594		1,916,583	11,677,575	21,783	41,851,427	41,851,427	(491,025)	(3,446)	(305,257)	(7,239)	(806,967)	83,744,154
S21	11,771,850	2,497,294		968,569	5,901,404	11,008	21,150,125	42,728,932	(248,145)	(1,742)	(154,265)	(3,658)	(407,810)	42,321,122
S22	2,039,432	432,648		167,801	1,022,398	1,907	3,664,186	7,402,639	(42,990)	(302)	(26,726)	(634)	(70,652)	7,331,988
S23	80,514,077	17,080,352		680,211	105,355,743	102,803	203,733,187	613,448,567	(1,013,230)	(5,194)	(183,694)		(1,202,118)	612,246,449
S24	3,789,661	803,943		32,016	4,958,916	4,839	9,589,376	28,873,985	(47,691)	(244)	(8,646)		(56,582)	28,817,403
S25				35,116,844	56,778,087	38,270,040	130,164,971	130,164,971	(9,890,693)	(14,931)	(1,427,891)	(63,209,227)	(74,542,742)	256,338,807
S26	14,397,116	4,279,051		(26,984,856)	33,518,500	121	25,209,932	25,209,932	(46,300,558)	(542,469)	(3,420,721)	(104)	(50,263,852)	115,305,769
S27	82,821,381	830,899	2,644,959	15,845,091	393,638,061	507,935	496,288,326	496,288,326	(155,228,685)	(3,831,057)	(4,094,470)	(558)	(163,154,770)	697,665,470
S28	22,140,215	1,661,271	18,085,976	34,670,191	59,098,123		135,655,776	135,655,776	(47,628,952)	(1,007,947)	(1,580,179)	(910,369)	(51,127,447)	399,582,393
S29	25,245,746	1,073,925	67,489,883	(34,678,469)	265,452,219	4,196,625	328,779,929	328,779,929	(1,130,010,967)	(14,945,767)	(45,999,442)	(1,446)	(1,190,957,622)	622,689,916
S30	91,980,087	35,596,575	590,807,081	320,955,845	1,017,765,537	412	2,057,105,537	1,813,647,538	(475,684,014)	(8,549,130)	(18,144,926)	(436,199)	(502,814,269)	2,636,401,074
S31	126,407,515	6,084,707	245,673,738	38,579,896	804,134,767	7,817,198	1,228,697,821	2,308,659,071	(1,148,672,313)	(8,179,824)	(19,920,130)	(3,040,345)	(1,179,812,612)	1,128,846,459
S32	205,916,019	9,847,001	462,513,643	(16,645,792)	625,630,607	41,428	1,287,302,906	1,848,211,745	(302,420,637)	(22,925,978)	(35,136,415)	(69,480)	(360,552,510)	1,487,659,235
S33	201,463,513	18,335,466	85,662,723	29,562,622	463,835,747	47,803,306	846,663,377	1,224,006,383	(213,558,591)	(2,311,200)	(7,808,299)	(45,921,128)	(269,599,218)	954,407,165
S34	103,381,426	27,175,089		4,622,781		506	135,179,802	715,134,934	(8,946,321)	(611)	(636,916)	(478)	(9,584,326)	705,550,608
S35	55,667,769	2,026,774		93,695,980	589,338		151,979,861	403,144,312	(233,327)	(1,760)	(4,819)		(239,906)	402,904,406
S36	21,140,660	8,442,707				202	29,583,569	58,502,568						58,502,568
S37	8,684,173	8,307,995	858,033,566				875,025,734	915,043,117						915,043,117
S38	731,168,284	18,601,965	194,920,182	37,752,414	380,677,829	39,682,047	1,402,802,721	2,937,049,236				(206,041,970)	(206,041,970)	2,937,049,236
S39	581,469,905	37,455,959	25,991,884	4,651,496	88,039,163	332,844,608	1,070,453,015	1,878,023,014				(104,941,551)	(104,941,551)	1,671,981,044
S40	541,740,864	27,840,624				230,119,705	799,701,193	936,403,857				(39,589,447)	(39,589,447)	831,462,306
S41	155,427,733	1,293,307,650				31,237,570	1,479,972,953	1,512,475,636				(103,661,937)	(103,661,937)	1,472,886,189
S42	502,449,084	79,505,003				87,817,553	669,771,640	1,735,910,045				(39,015,412)	(39,015,412)	1,632,248,108
S43	345,902,816	6,584,525				80,977,657	433,464,998	607,842,342	(264)	(1)	(2)	(26,751,279)	(26,751,546)	568,826,930
S44	110,151,796	20,026,530			2,000,002	17,793,170	149,971,498	241,389,544						214,637,998
190	5,894,798,196	1,697,861,980	2,593,168,109	531,017,026	6,111,176,822	1,025,168,237	17,853,190,370	34,282,956,870	(5,694,872,529)	(91,595,066)	(265,869,286)	(715,926,654)	(6,768,263,535)	27,514,693,335

Table A-2 Input-Output Table 40x40 (Continue)

Brazil's Input-Out table for biofuel production from the Brazilian Institute of Geography and Statistics, the year 2015 showed in **Table A-3**

Table A-3 Brazil's Input-Output Table for biofuel production

IO Code	Sector Clarification	Intermediate Input of Biofuel production (x10^6 Brazilian real)	Ratio
01913	Upland cotton, other fibers temporary crops	59	0.17%
01914	Sugar cane	17,784	52.06%
01915	Soy bean	1,573	4.60%
01916	Other goods and services of temporary crops	389	1.14%
02801	forestry and forestry products	1	0.00%
05802	Non-Metallic Minerals	313	0.92%
10911	Beef cattle and other meat products	1,035	3.03%
10921	Sugar	904	2.65%
10932	Vegetable oils and animal fats	2,274	6.66%
17002	Paper, cardboard, packaging and paper artifacts	63	0.18%
18001	Service printing and reproduction	12	0.04%
19915	Diesel - Biodiesel	1,147	3.36%
19921	Ethanol and other biofuels	512	1.50%
20911	Inorganic Chemicals	16	0.05%
20913	organic chemicals	1,198	3.51%
20922	various chemicals	242	0.71%
20931	Perfumes, soaps and cleaning articles	1	0.00%
22002	Plastic products	48	0.14%
25001	metal products, except machinery and equipment	79	0.23%
27001	Machinery, appliances and equipment	12	0.04%
31802	Products of various industries	2	0.01%
33001	Maintenance, repair and installation of machinery and equipment	900	2.63%
35001	Electricity, gas and other utilities	172	0.50%
36801	Water, sewage, recycling and waste management	28	0.08%
41801	buildings	27	0.08%
45801	Wholesale trade and retail	418	1.22%
49001	Inland freight transport	857	2.51%
49002	Overland transport of passengers	60	0.18%
50001	Water transportation	16	0.05%
51001	Air Transport	4	0.01%

IO Code	Sector Clarification	Intermediate Input of Biofuel production (x10^6 Brazilian real)	Ratio
52801	Storage and ancillary services to transport	865	2.53%
52802	Mail and other delivery services	21	0.06%
55001	accommodation services in hotels and similar	19	0.06%
56001	food services	1	0.00%
61001	Telecommunications, cable TV and other related services	134	0.39%
62801	Systems development and other information services	2	0.01%
64801	Financial intermediation, insurance and pension plan	1,183	3.46%
68001	effective rental and real estate services	184	0.54%
69801	legal, accounting and consulting	589	1.72%
71802	Service architecture and engineering	333	0.97%
73801	Advertising and other technical services	106	0.31%
77001	Rents not real estate and management of intellectual property assets	105	0.31%
78801	Condos and services for buildings	404	1.18%
78802	Other administrative services	21	0.06%
80001	Services Surveillance, Security and investigation	1	0.00%
94801	Employers organizations, trade unions and other associations services	47	0.14%
	Total	34,161	

Japan's Input-Out table for gasoline consumption from IBGE Ministry of Internal

Affairs and Communications, the year 2015 showed in **Table A-4**

Table A-4 Japan's Input-Out table for gasoline consumption

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
011101	Rice	6,774.00	0.11%
011102	Wheat, barley and the like	166.00	0.00%
011201	Potatoes and sweet potatoes	832.00	0.01%
011202	Pulses	248.00	0.00%
011301	Vegetables (outdoor)	3,070.00	0.05%
011302	Vegetables (under facilities)	1,002.00	0.02%
011401	Fruits	3,128.00	0.05%
011501	Sugar crops	312.00	0.00%
011502	Crops for beverages	366.00	0.01%
011509	Miscellaneous edible crops	300.00	0.00%
011601	Feed and forage crops	590.00	0.01%
011602	Seeds and seedlings	116.00	0.00%
011603	Flowers and plants	1,264.00	0.02%
011609	Miscellaneous inedible crops	150.00	0.00%
012101	Dairy cattle farming	296.00	0.00%
012102	Beef cattle	610.00	0.01%
012103	Hogs	414.00	0.01%
012104	Hen eggs	686.00	0.01%
012105	Chickens	786.00	0.01%
012109	Miscellaneous livestock	96.00	0.00%
013102	Agricultural services (except veterinary service)	1,044.00	0.02%
015101	Silviculture	236.00	0.00%
015201	Logs	122.00	0.00%
015301	Special forest products (including hunting)	4,512.00	0.07%
017101	Marine fishery	5,338.00	0.08%
017102	Marine aquaculture	3,020.00	0.05%
017201	Inland water fishery	1,276.00	0.02%
017202	Inland water aquaculture	168.00	0.00%
061101	Coal mining, crude petroleum and natural gas	2.00	0.00%
062101	Gravel and quarrying	94.00	0.00%
063101		1,280.00	0.02%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
063102		116.00	0.00%
063909		32.00	0.00%
112101	Refined sake	342.00	0.01%
112102	Malt liquors	18.00	0.00%
112109	Miscellaneous liquors	90.00	0.00%
114101	Tobacco	6.00	0.00%
151101	Fiber yarns	518.00	0.01%
151201	Cotton and staple fiber fabrics (including fabrics of synthetic spun fibers)	70.00	0.00%
151202	Silk and artificial silk fabrics (including fabrics of synthetic filament fibers)	112.00	0.00%
151209	Miscellaneous fabrics	50.00	0.00%
151301	Knitting fabrics	80.00	0.00%
151401	Yarn and fabric dyeing and finishing (processing on commission only)	14.00	0.00%
151909	Miscellaneous fabricated textile products	312.00	0.00%
152101	Woven fabric apparel	412.00	0.01%
152102	Knitted apparel	184.00	0.00%
152209	Miscellaneous wearing apparel and clothing accessories	96.00	0.00%
152901	Bedding	32.00	0.00%
152902	Carpets and floor mats	116.00	0.00%
152909	Miscellaneous ready-made textile products	382.00	0.01%
161101	Timber	138.00	0.00%
161102	Plywood, glued laminated timber	40.00	0.00%
161909	Miscellaneous wooden products	850.00	0.01%
162101	Wooden furniture	74.00	0.00%
162102	Metallic furniture	42.00	0.00%
162103	Wooden fixtures	454.00	0.01%
162109	Miscellaneous furniture and fixtures	30.00	0.00%
163201	Paper	20.00	0.00%
163202	Paperboard	426.00	0.01%
163301	Corrugated cardboard	126.00	0.00%
163302	Coated paper and building (construction) paper	558.00	0.01%
164101	Corrugated card board boxes	594.00	0.01%
164109	Miscellaneous paper containers	214.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
164901	Paper textile for medical use	458.00	0.01%
164909	Miscellaneous pulp, paper and processed paper products	456.00	0.01%
191101	Printing, plate making and book binding	778.00	0.01%
202101	Industrial soda chemicals	8.00	0.00%
202901	Inorganic pigment	10.00	0.00%
202903	Salt	2.00	0.00%
202909	Miscellaneous industrial inorganic chemicals	2,758.00	0.04%
204103		2.00	0.00%
204909	Miscellaneous industrial organic chemicals	190.00	0.00%
206101	Chemical fibers	6.00	0.00%
206102		24.00	0.00%
207101	Medicaments	900.00	0.01%
208101	Oil and fat products and surface-active agents	40.00	0.00%
208401	Agricultural chemicals	174.00	0.00%
211101	Petroleum refinery products (including greases)	629,827.00	10.02%
212101	Coal products	52.00	0.00%
222101	Tires and inner tubes	1,738.00	0.03%
222901		48.00	0.00%
222909	Miscellaneous rubber products	1,424.00	0.02%
231101	Leather footwear	8.00	0.00%
231201	Leather tanning, leather products and fur skins (except leather footwear)	20.00	0.00%
231202		280.00	0.00%
251101	Sheet glass and safety glass	552.00	0.01%
251102	Glass fiber and glass fiber products, n.e.c.	154.00	0.00%
251109	Miscellaneous glass products	138.00	0.00%
252101	Cement	28.00	0.00%
252103	Cement products	296.00	0.00%
253101	Pottery, china and earthenware	158.00	0.00%
259101	Clay refractories	54.00	0.00%
259109	Miscellaneous structural clay products	208.00	0.00%
259901	Carbon and graphite products	102.00	0.00%
259902	Abrasive and its products	22.00	0.00%
259909	Miscellaneous ceramic, stone and clay products	528.00	0.01%
261102	Ferro-alloys	24.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
262302	Coated steel	8.00	0.00%
263101	Cast and forged steel	20.00	0.00%
263102	Cast iron pipes and tubes	32.00	0.00%
263103	Cast and forged materials (iron)	8.00	0.00%
269901	Iron and steel shearing and slitting	32.00	0.00%
269909	Miscellaneous iron or steel products	210.00	0.00%
271101	Copper	62.00	0.00%
271102	Lead and zinc (including regenerated lead)	134.00	0.00%
271103	Aluminum (including regenerated aluminum)	146.00	0.00%
271109	Miscellaneous non-ferrous metals	66.00	0.00%
272101	Electric wires and cables	42.00	0.00%
272102	Optical fiber cables	10.00	0.00%
272901	Rolled and drawn copper and copper alloys	90.00	0.00%
272902	Rolled and drawn aluminum	200.00	0.00%
272903	Non-ferrous metal castings and forgings	114.00	0.00%
272909	Miscellaneous non-ferrous metal products	198.00	0.00%
281101	Fabricated construction-use metal products	92.00	0.00%
281201	Fabricated architectural metal products	1,754.00	0.03%
289101	Gas and oil appliances, heating and cooking apparatus	58.00	0.00%
289901	Bolts, nuts, rivets and springs	154.00	0.00%
289902	Metal containers, fabricated plate and sheet metal	42.00	0.00%
289903	Plumbing accessories, powder metallurgy products and tools	62.00	0.00%
289909	Miscellaneous metal products	5,318.00	0.08%
291101	Boilers	2.00	0.00%
291102	Turbines	2.00	0.00%
291103	Engines	366.00	0.01%
291201	Pumps and compressors	70.00	0.00%
291301	Conveyors	462.00	0.01%
291401	Refrigerators and air conditioning apparatus	82.00	0.00%
291901	Bearings	70.00	0.00%
291909	Miscellaneous general-purpose machinery	138.00	0.00%
301101	Machinery for agricultural use	102.00	0.00%
301201	Machinery and equipment for construction and mining	698.00	0.01%
301301	Textile machinery	110.00	0.00%
301401	Daily lives industry machinery	120.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10⁶ YEN)	Ratio
301501	Chemical machinery	226.00	0.00%
301502	Casting equipment and plastic processing machinery	102.00	0.00%
301601	Metal machine tools	8.00	0.00%
301602	Metal processing machinery	8.00	0.00%
301603	Machinists' precision tools	18.00	0.00%
301701	Semiconductor making equipment	22.00	0.00%
301901	Metal molds	142.00	0.00%
301902	Vacuum equipment and vacuum component	8.00	0.00%
301903	Robots	36.00	0.00%
301909	Miscellaneous production machinery	204.00	0.00%
311101	Copy machine	54.00	0.00%
311109	Miscellaneous office machines	2.00	0.00%
311201	Service industry and amusement machines	18.00	0.00%
311301	Measuring instruments	2,062.00	0.03%
311401	Medical instruments	1,010.00	0.02%
311501	Optical instruments and lenses	464.00	0.01%
311601	Ordnance	42.00	0.00%
321101	Semiconductor devices	22.00	0.00%
321102	Integrated circuits	266.00	0.00%
321103	Liquid crystal panel	232.00	0.00%
321104	Flat-panel and electron tubes	334.00	0.01%
329901	Storage media	66.00	0.00%
329902	Electric circuit	1,842.00	0.03%
329909	Miscellaneous electronic components	5,644.00	0.09%
331101	Rotating electrical equipment	496.00	0.01%
331102	Transformers and reactors	216.00	0.00%
331103	Relay switches and switchboards	668.00	0.01%
331104	Wiring devices and supplies	86.00	0.00%
331105	Electrical equipment for internal combustion engines	90.00	0.00%
332101	Household air-conditioners	20.00	0.00%
332102	Household electric appliances (except air-conditioners)	242.00	0.00%
333101	Applied electronic equipment	150.00	0.00%
333201	Electric measuring instruments	304.00	0.00%
339901	Electric bulbs	124.00	0.00%
339902	Electric lighting fixtures and apparatus	194.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10⁶ YEN)	Ratio
339903	Batteries	654.00	0.01%
339909	Miscellaneous electrical devices and parts	550.00	0.01%
341101	Wired communication equipment	94.00	0.00%
341102	Mobile phone	70.00	0.00%
341103	Radio communication equipment (except mobile phone)	396.00	0.01%
341201	Radio and television sets	54.00	0.00%
341202	Miscellaneous communication equipment	2.00	0.00%
341203	Video equipment and digital camera	142.00	0.00%
341209	Electric audio equipment	116.00	0.00%
342101	Personal Computers	20.00	0.00%
342103	Electronic computing equipment (accessory equipment)	322.00	0.01%
351101	Passenger motor cars	22,674.00	0.36%
352101	Trucks, buses and miscellaneous cars	1,230.00	0.02%
352201	Two-wheel motor vehicles	90.00	0.00%
353101	Internal combustion engines for motor vehicles	2,160.00	0.03%
353102	Motor vehicle parts and accessories	4,494.00	0.07%
354101	Steel ships	80.00	0.00%
354102	Miscellaneous Ships (except steel ships)	30.00	0.00%
354103	Internal combustion engines for vessels	158.00	0.00%
354110	Repair of ships	32.00	0.00%
359101	Rolling stock	460.00	0.01%
359110	Repair of rolling stock	1,948.00	0.03%
359201	Aircrafts	164.00	0.00%
359210	Repair of aircrafts	22.00	0.00%
359901	Bicycles	24.00	0.00%
359909	Miscellaneous transport equipment	308.00	0.00%
391101	Toys and games	136.00	0.00%
391102	Sporting and athletic goods	282.00	0.00%
391901	Jewelry and adornments	186.00	0.00%
391902	Watches and clocks	152.00	0.00%
391904	Stationery	138.00	0.00%
391906	Audio and video records, other information recording media	172.00	0.00%
391909	Miscellaneous manufacturing products	78.00	0.00%
392101	Reuse and recycling	322.00	0.01%
411101	Residential construction (wooden)	3,374.00	0.05%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10⁶ YEN)	Ratio
411102	Residential construction (non-wooden)	7,484.00	0.12%
411201	Non-residential construction (wooden)	372.00	0.01%
411202	Non-residential construction (non-wooden)	9,802.00	0.16%
412101	Repair of construction	18,406.00	0.29%
413101	Public construction of roads	22,556.00	0.36%
413102	Public construction of rivers, drainages and miscellaneous public construction	6,028.00	0.10%
413103	Agricultural public construction	1,300.00	0.02%
419101	Railway construction	886.00	0.01%
419102	Electric power facilities construction	894.00	0.01%
419103	Telecommunication facilities construction	142.00	0.00%
419109	Miscellaneous civil engineering and construction	4,590.00	0.07%
471103	Sewage disposal **	7,622.00	0.12%
481101	Waste management services (public corporation) **	3,920.00	0.06%
481102	Waste management services	9,790.00	0.16%
531201	Life insurance	126.00	0.00%
572101	Bus transport service	1,468.00	0.02%
572102	Hired car and taxi transport	5,082.00	0.08%
572201	Road freight transport (except self-transport)	38,106.00	0.61%
573101	Self-transport (passengers)	4,085,426.00	65.01%
573201	Self-transport (freight)	870,224.00	13.85%
574301	Harbor transport service	6,462.00	0.10%
575101	Air transport	6,570.00	0.10%
576101	Consigned freight forwarding	4,636.00	0.07%
577101	Storage facility service	1,278.00	0.02%
578101	Packing service	2,762.00	0.04%
578901	Facility service for road transport	4,422.00	0.07%
578904	Services relating to water transport	446.00	0.01%
578905	Airport and air traffic control (public corporation) **	280.00	0.00%
578906	Airport and air traffic control	1,464.00	0.02%
579101	Postal services and mail delivery	21,048.00	0.33%
595101	Video picture, sound information, character information production (except newspaper or publication)	2,444.00	0.04%
595102	Newspaper	2,534.00	0.04%
595103	Publication	3,346.00	0.05%

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
611101	Public administration (central government) **	26,421.00	0.42%
611201	Public administration (local government) **	79,834.00	1.27%
631101	School education (public institution) **	2,520.00	0.04%
631102	School education (NPI) *	2,792.00	0.04%
631204	Miscellaneous educational and training institutions	19,530.00	0.31%
632101	Research institutes for natural science (public institution) **	20,516.00	0.33%
632103	Research institutes for natural sciences (NPI) *	8,348.00	0.13%
632105	Research institutes for natural sciences	19,224.00	0.31%
632201	Research and development (intra-enterprise)	22,236.00	0.35%
641101	Medical service (hospitalization)	808.00	0.01%
641102	Medical service (except hospitalization)	1,386.00	0.02%
661201	Car rental and leasing	18,500.00	0.29%
663110	Motor vehicle maintenance services	8,608.00	0.14%
663210	Machine repair services	26,570.00	0.42%
672101	Eating and drinking places	16,916.00	0.27%
673101	Cleaning	8,368.00	0.13%
674103	Stadiums and companies of bicycle, horse, motorcar and motorboat races	304.00	0.00%
674104	Sport facility service, public gardens and amusement parks	30.00	0.00%
674109	Miscellaneous amusement and recreation services	416.00	0.01%
679902	Ceremonial occasions	1,208.00	0.02%
691100	Activities not elsewhere classified	93,458.00	1.49%
700000	Total of intermediate sectors	6,283,852.00	
721100	Consumption expenditure of households	12,388,201.00	
761101	Increase in producer's stocks of finished goods	17,042.00	
761102	Increase in semi-finished goods and work-in-progress	10,862.00	
761103	Increase in dealer's stocks of goods	64,056.00	
761104	Increase in stocks of raw materials and supplies	-18,346.00	
771100		10,392.00	
780000	Total domestic final demand	12,472,207.00	
790000	Total domestic demand	18,756,059.00	
801101	Exports (ordinary trade)	247,402.00	
801102	Exports (special trade)	16,482.00	
801200	Exports (direct purchase)	2,480.00	
810000	Exports total	266,364.00	

IO Code	Sector Clarification	Intermediate Input of Gasoline consumption (x10^6 YEN)	Ratio
820000	Total Final demand	12,738,571.00	
830000	Total demand	19,022,423.00	
841101	(less) Imports (ordinary trade)	-478,698.00	
841102	(less) Imports (special trade)	-903.00	
841200	(less) Imports (direct purchase)	-7,755.00	
851100	(less) Custom duties	-6,429.00	
861100	(less) Commodity taxes on imported goods	-135,084.00	
870000	(less) Total imports	-628,869.00	
880000	Total of final demand sectors	12,109,702.00	
891100	Trade margins (wholesale)	-1,537,894.00	
891200	Trade margins (retail)	-3,460,402.00	
901100	Transportation charges (railway)	-10,006.00	
901200	Transportation charges (road)	-30,964.00	
901301	Transportation charges (coastal and inland water)	-82,794.00	
901302	Transportation charges (harbor)	-4,706.00	
901500	Transportation charges (forwarding)	-18,188.00	
901600	Transportation charges (storage facility)	-43,982.00	
970000	Domestic production (gross outputs)	13,204,618.00	
Grand Total		107,429,545.00	

Japan's Input-Out table for diesel consumption from IBGE Ministry of Internal Affairs and Communications, the year 2015 showed in **Table A-5**

Table A-5 Japan's Input-Out table for diesel consumption

IO Code	Sector Clarification	Intermediate Input of Diesel consumption ($\times 10^6$ YEN)	Ratio
011101	Rice	20,174.00	0.29%
011102	Wheat, barley and the like	872.00	0.01%
011201	Potatoes and sweet potatoes	3,890.00	0.06%
011202	Pulses	1,366.00	0.02%
011301	Vegetables (outdoor)	4,742.00	0.07%
011302	Vegetables (under facilities)	938.00	0.01%
011401	Fruits	3,718.00	0.05%
011501	Sugar crops	828.00	0.01%
011502	Crops for beverages	192.00	0.00%
011509	Miscellaneous edible crops	1,200.00	0.02%
011601	Feed and forage crops	3,102.00	0.04%
011602	Seeds and seedlings	18.00	0.00%
011603	Flowers and plants	698.00	0.01%
011609	Miscellaneous inedible crops	76.00	0.00%
012101	Dairy cattle farming	2,274.00	0.03%
012102	Beef cattle	558.00	0.01%
012103	Hogs	416.00	0.01%
012104	Hen eggs	1,282.00	0.02%
012105	Chickens	100.00	0.00%
012109	Miscellaneous livestock	76.00	0.00%
013102	Agricultural services (except veterinary service)	556.00	0.01%
015101	Silviculture	1,236.00	0.02%
015201	Logs	14,124.00	0.20%
015301	Special forest products (including hunting)	16.00	0.00%
017101	Marine fishery	4,432.00	0.06%
017102	Marine aquaculture	512.00	0.01%
017201	Inland water fishery	140.00	0.00%
017202	Inland water aquaculture	158.00	0.00%
061101	Coal mining, crude petroleum and natural gas	414.00	0.01%
062101	Gravel and quarrying	884.00	0.01%
063101		6,872.00	0.10%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
063102		20,022.00	0.28%
063909		4,890.00	0.07%
111201	Frozen fish and shellfish	60.00	0.00%
111202	Salted, dried or smoked seafood	8.00	0.00%
111203	Bottled or canned seafood	1,238.00	0.02%
111301	Grain milling	1,120.00	0.02%
111302	Flour and miscellaneous grain milled products	38.00	0.00%
111303		4.00	0.00%
111309		2.00	0.00%
111401	Noodles	820.00	0.01%
111402	Bread	10.00	0.00%
111501	Preserved agricultural foodstuffs	92.00	0.00%
111502		1,996.00	0.03%
111503		10.00	0.00%
111601	Sugar	54.00	0.00%
111602	Starch	216.00	0.00%
111701		58.00	0.00%
111702		40.00	0.00%
111704		30.00	0.00%
111705		610.00	0.01%
111901	Prepared frozen foods	30.00	0.00%
111903	Dishes, sushi and lunch boxes	160.00	0.00%
111909	Miscellaneous foods	9,406.00	0.13%
112101	Refined sake	32.00	0.00%
112109	Miscellaneous liquors	6.00	0.00%
112901	Tea and roasted coffee	1,578.00	0.02%
112902	Soft drinks	480.00	0.01%
113101	Feeds	3,860.00	0.05%
113102	Organic fertilizers, n.e.c.	728.00	0.01%
114101	Tobacco	50.00	0.00%
151101	Fiber yarns	378.00	0.01%
151201	Cotton and staple fiber fabrics (including fabrics of synthetic spun fibers)	2.00	0.00%
151202	Silk and artificial silk fabrics (including fabrics of synthetic filament fibers)	6.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
151209	Miscellaneous fabrics	2.00	0.00%
151301	Knitting fabrics	60.00	0.00%
151401	Yarn and fabric dyeing and finishing (processing on commission only)	72.00	0.00%
151909	Miscellaneous fabricated textile products	60.00	0.00%
152101	Woven fabric apparel	304.00	0.00%
152102	Knitted apparel	134.00	0.00%
152209	Miscellaneous wearing apparel and clothing accessories	68.00	0.00%
152901	Bedding	96.00	0.00%
152902	Carpets and floor mats	2.00	0.00%
152909	Miscellaneous ready-made textile products	446.00	0.01%
161101	Timber	2,232.00	0.03%
161102	Plywood, glued laminated timber	1,004.00	0.01%
161103	Wooden chips	1,498.00	0.02%
161909	Miscellaneous wooden products	400.00	0.01%
162101	Wooden furniture	278.00	0.00%
162102	Metallic furniture	22.00	0.00%
162103	Wooden fixtures	172.00	0.00%
162109	Miscellaneous furniture and fixtures	54.00	0.00%
163101	Pulp	578.00	0.01%
163201	Paper	180.00	0.00%
163202	Paperboard	278.00	0.00%
163301	Corrugated cardboard	408.00	0.01%
163302	Coated paper and building (construction) paper	1,730.00	0.02%
164101	Corrugated card board boxes	1,828.00	0.03%
164109	Miscellaneous paper containers	658.00	0.01%
164901	Paper textile for medical use	1,472.00	0.02%
164909	Miscellaneous pulp, paper and processed paper products	1,620.00	0.02%
191101	Printing, plate making and book binding	152.00	0.00%
202903	Salt	4.00	0.00%
202909	Miscellaneous industrial inorganic chemicals	598.00	0.01%
203102	Petrochemical aromatic products (except synthetic resin)	8.00	0.00%
204102	Cyclic intermediates, synthetic dyes and organic pigments	86.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
204103		26.00	0.00%
204201	Synthetic rubber	98.00	0.00%
204901	Methane derivatives	262.00	0.00%
206101	Chemical fibers	66.00	0.00%
206102		444.00	0.01%
207101	Medicaments	9,766.00	0.14%
208101	Oil and fat products and surface-active agents	98.00	0.00%
211101	Petroleum refinery products (including greases)	144,981.00	2.05%
212101	Coal products	58.00	0.00%
212102	Paving materials	64.00	0.00%
221101	Plastic products	392.00	0.01%
222101	Tires and inner tubes	960.00	0.01%
222909	Miscellaneous rubber products	906.00	0.01%
231101	Leather footwear	2.00	0.00%
231201	Leather tanning, leather products and fur skins (except leather footwear)	8.00	0.00%
231202		50.00	0.00%
251101	Sheet glass and safety glass	4.00	0.00%
251102	Glass fiber and glass fiber products, n.e.c.	8.00	0.00%
251109	Miscellaneous glass products	12.00	0.00%
252101	Cement	972.00	0.01%
252102	Ready mixed concrete	19,628.00	0.28%
252103	Cement products	5,974.00	0.08%
253101	Pottery, china and earthenware	9,536.00	0.13%
259101	Clay refractories	1,138.00	0.02%
259109	Miscellaneous structural clay products	234.00	0.00%
259901	Carbon and graphite products	2,200.00	0.03%
259902	Abrasive and its products	408.00	0.01%
259909	Miscellaneous ceramic, stone and clay products	2,106.00	0.03%
261101	Pig iron	2.00	0.00%
261102	Ferro-alloys	190.00	0.00%
261103	Crude steel (converters)	216.00	0.00%
261104	Crude steel (electric furnaces)	2.00	0.00%
262302	Coated steel	4.00	0.00%
263101	Cast and forged steel	116.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
263102	Cast iron pipes and tubes	88.00	0.00%
263103	Cast and forged materials (iron)	52.00	0.00%
269901	Iron and steel shearing and slitting	126.00	0.00%
269909	Miscellaneous iron or steel products	420.00	0.01%
271101	Copper	238.00	0.00%
271102	Lead and zinc (including regenerated lead)	70.00	0.00%
271103	Aluminum (including regenerated aluminum)	604.00	0.01%
271109	Miscellaneous non-ferrous metals	248.00	0.00%
272101	Electric wires and cables	160.00	0.00%
272102	Optical fiber cables	42.00	0.00%
272901	Rolled and drawn copper and copper alloys	372.00	0.01%
272902	Rolled and drawn aluminum	172.00	0.00%
272903	Non-ferrous metal castings and forgings	126.00	0.00%
272909	Miscellaneous non-ferrous metal products	180.00	0.00%
281101	Fabricated construction-use metal products	1,440.00	0.02%
281201	Fabricated architectural metal products	2,108.00	0.03%
289101	Gas and oil appliances, heating and cooking apparatus	34.00	0.00%
289901	Bolts, nuts, rivets and springs	62.00	0.00%
289902	Metal containers, fabricated plate and sheet metal	16.00	0.00%
289903	Plumbing accessories, powder metallurgy products and tools	10.00	0.00%
289909	Miscellaneous metal products	126.00	0.00%
291101	Boilers	50.00	0.00%
291102	Turbines	10.00	0.00%
291103	Engines	198.00	0.00%
291201	Pumps and compressors	190.00	0.00%
291301	Conveyors	60.00	0.00%
291401	Refrigerators and air conditioning apparatus	16.00	0.00%
291901	Bearings	218.00	0.00%
291909	Miscellaneous general-purpose machinery	88.00	0.00%
301101	Machinery for agricultural use	124.00	0.00%
301201	Machinery and equipment for construction and mining	1,174.00	0.02%
301301	Textile machinery	22.00	0.00%
301401	Daily lives industry machinery	52.00	0.00%
301501	Chemical machinery	182.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
301502	Casting equipment and plastic processing machinery	42.00	0.00%
301601	Metal machine tools	50.00	0.00%
301602	Metal processing machinery	30.00	0.00%
301701	Semiconductor making equipment	16.00	0.00%
301901	Metal molds	36.00	0.00%
301902	Vacuum equipment and vacuum component	16.00	0.00%
301909	Miscellaneous production machinery	86.00	0.00%
311109	Miscellaneous office machines	2.00	0.00%
311201	Service industry and amusement machines	22.00	0.00%
311301	Measuring instruments	28.00	0.00%
311401	Medical instruments	242.00	0.00%
311501	Optical instruments and lenses	152.00	0.00%
311601	Ordnance	36.00	0.00%
321101	Semiconductor devices	10.00	0.00%
321102	Integrated circuits	146.00	0.00%
321103	Liquid crystal panel	28.00	0.00%
321104	Flat-panel and electron tubes	192.00	0.00%
329901	Storage media	40.00	0.00%
329902	Electric circuit	266.00	0.00%
329909	Miscellaneous electronic components	552.00	0.01%
331101	Rotating electrical equipment	210.00	0.00%
331103	Relay switches and switchboards	284.00	0.00%
331104	Wiring devices and supplies	34.00	0.00%
331105	Electrical equipment for internal combustion engines	52.00	0.00%
332101	Household air-conditioners	6.00	0.00%
332102	Household electric appliances (except air-conditioners)	90.00	0.00%
333201	Electric measuring instruments	66.00	0.00%
339902	Electric lighting fixtures and apparatus	86.00	0.00%
339903	Batteries	252.00	0.00%
339909	Miscellaneous electrical devices and parts	8.00	0.00%
341102	Mobile phone	36.00	0.00%
341103	Radio communication equipment (except mobile phone)	368.00	0.01%
341201	Radio and television sets	46.00	0.00%
341203	Video equipment and digital camera	172.00	0.00%
341209	Electric audio equipment	90.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
342101	Personal Computers	28.00	0.00%
342102	Electronic computing equipment (except personal computers)	48.00	0.00%
342103	Electronic computing equipment (accessory equipment)	176.00	0.00%
351101	Passenger motor cars	1,488.00	0.02%
352101	Trucks, buses and miscellaneous cars	684.00	0.01%
352201	Two-wheel motor vehicles	58.00	0.00%
353101	Internal combustion engines for motor vehicles	1,052.00	0.01%
353102	Motor vehicle parts and accessories	3,630.00	0.05%
354101	Steel ships	1,954.00	0.03%
354102	Miscellaneous Ships (except steel ships)	62.00	0.00%
354103	Internal combustion engines for vessels	458.00	0.01%
354110	Repair of ships	36.00	0.00%
359101	Rolling stock	78.00	0.00%
359110	Repair of rolling stock	88.00	0.00%
359201	Aircrafts	88.00	0.00%
359901	Bicycles	10.00	0.00%
359909	Miscellaneous transport equipment	908.00	0.01%
391101	Toys and games	100.00	0.00%
391102	Sporting and athletic goods	126.00	0.00%
391901	Jewelry and adornments	216.00	0.00%
391902	Watches and clocks	70.00	0.00%
391903	Musical instruments	66.00	0.00%
391904	Stationery	368.00	0.01%
391905	"Tatami" (straw matting) and straw products	22.00	0.00%
391909	Miscellaneous manufacturing products	952.00	0.01%
392101	Reuse and recycling	5,764.00	0.08%
411101	Residential construction (wooden)	3,470.00	0.05%
411102	Residential construction (non-wooden)	6,424.00	0.09%
411201	Non-residential construction (wooden)	516.00	0.01%
411202	Non-residential construction (non-wooden)	14,100.00	0.20%
412101	Repair of construction	26,438.00	0.37%
413101	Public construction of roads	151,960.00	2.15%
413102	Public construction of rivers, drainages and miscellaneous public construction	90,974.00	1.29%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
413103	Agricultural public construction	58,646.00	0.83%
419101	Railway construction	14,228.00	0.20%
419102	Electric power facilities construction	5,722.00	0.08%
419103	Telecommunication facilities construction	696.00	0.01%
419109	Miscellaneous civil engineering and construction	57,918.00	0.82%
461102	Electricity (except thermal power)	16,692.00	0.24%
461104		30,764.00	0.44%
471101	Water supply	54.00	0.00%
471102	Industrial water supply	628.00	0.01%
471103	Sewage disposal **	5,390.00	0.08%
481101	Waste management services (public corporation) **	5,960.00	0.08%
481102	Waste management services	13,826.00	0.20%
511101	Wholesale trade	46,606.00	0.66%
511201	Retail trade	35,704.00	0.51%
531101	Financial service	4,366.00	0.06%
531201	Life insurance	1,204.00	0.02%
531202	Non-life insurance	70.00	0.00%
551101	Real estate agencies and managers	1,876.00	0.03%
551102	Real estate rental service	44,592.00	0.63%
552101	House rent	13,372.00	0.19%
571101	Railway transport (passengers)	36,012.00	0.51%
571201	Railway transport (freight)	3,410.00	0.05%
572101	Bus transport service	315,790.00	4.47%
572102	Hired car and taxi transport	2,552.00	0.04%
572201	Road freight transport (except self-transport)	2,077,180.00	29.40%
573101	Self-transport (passengers)	582,728.00	8.25%
573201	Self-transport (freight)	1,985,816.00	28.11%
574101	International shipping	2,500.00	0.04%
574201	Coastal and inland water transport	46,784.00	0.66%
574301	Harbor transport service	21,644.00	0.31%
575101	Air transport	670.00	0.01%
576101	Consigned freight forwarding	40,116.00	0.57%
577101	Storage facility service	3,284.00	0.05%
578101	Packing service	1,396.00	0.02%
578901	Facility service for road transport	11,898.00	0.17%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
578902	Port and water traffic control (public corporation) **	290.00	0.00%
578903	Port and water traffic control	190.00	0.00%
578904	Services relating to water transport	126.00	0.00%
578905	Airport and air traffic control (public corporation) **	582.00	0.01%
578906	Airport and air traffic control	13,398.00	0.19%
593101	Information services	28,150.00	0.40%
595101	Video picture, sound information, character information production (except newspaper or publication)	3,302.00	0.05%
595102	Newspaper	12.00	0.00%
611101	Public administration (central government) **	30,722.00	0.43%
611201	Public administration (local government) **	88,570.00	1.25%
631101	School education (public institution) **	2,754.00	0.04%
631102	School education (NPI) *	992.00	0.01%
631201	Social education (public institution) **	188.00	0.00%
631202	Social education (NPI) *	130.00	0.00%
631203	Miscellaneous educational and training institutions (public institution) **	10,046.00	0.14%
631204	Miscellaneous educational and training institutions	27,310.00	0.39%
632101	Research institutes for natural science (public institution) **	8,270.00	0.12%
632102	Research institutes for cultural and social science (public institution) **	4,556.00	0.06%
632103	Research institutes for natural sciences (NPI) *	4,010.00	0.06%
632104	Research institutes for cultural and social science (NPI) *	242.00	0.00%
632105	Research institutes for natural sciences	67,940.00	0.96%
632106	Research institutes for cultural and social science	16.00	0.00%
632201	Research and development (intra-enterprise)	123,448.00	1.75%
641101	Medical service (hospitalization)	20,604.00	0.29%
641102	Medical service (except hospitalization)	24,986.00	0.35%
641103	Medical service (dentistry)	12,132.00	0.17%
641104	Medical service (pharmacy dispensing)	3,358.00	0.05%
641105	Medical service (miscellaneous medical service)	20,206.00	0.29%
642101	Health and hygiene (public institution) **	6,590.00	0.09%
642102	Health and hygiene	4,036.00	0.06%
643101	Social insurance **	42.00	0.00%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
643102	Social welfare (public institution) **	4,306.00	0.06%
643103	Social welfare (NPI) *	3,658.00	0.05%
643104	Social welfare	1,718.00	0.02%
644101	Nursing care (facility services)	4,160.00	0.06%
644102	Nursing care (except facility services)	5,686.00	0.08%
659901	Membership-based business associations	3,268.00	0.05%
659902	Private non-profit institutions serving households, n.e.c. *	5,776.00	0.08%
661101	Goods rental and leasing (except car rental)	11,114.00	0.16%
661201	Car rental and leasing	14,580.00	0.21%
662101	Advertising services	5,360.00	0.08%
663110	Motor vehicle maintenance services	10,278.00	0.15%
663210	Machine repair services	14,926.00	0.21%
669901	Judicial, financial and accounting services	2,696.00	0.04%
669902	Civil engineering and construction services	12,892.00	0.18%
669903	Worker dispatching services	184.00	0.00%
669904	Building maintenance services	24,630.00	0.35%
669909	Miscellaneous business services	46,230.00	0.65%
671101	Hotels	12,688.00	0.18%
672101	Eating and drinking places	34,090.00	0.48%
673101	Cleaning	13,576.00	0.19%
674101	Movie theaters	238.00	0.00%
674102	Performances (except movie theaters), theatrical comranies	274.00	0.00%
674103	Stadiums and companies of bicycle, horse, motorcar and motorboat races	6,314.00	0.09%
674104	Sport facility service, public gardens and amusement parks	18,140.00	0.26%
674105	Amusement and recreation facilities	12,704.00	0.18%
674109	Miscellaneous amusement and recreation services	778.00	0.01%
679901	Photographic studios	1,120.00	0.02%
679902	Ceremonial occasions	12,838.00	0.18%
679903	Supplementary tutorial schools, instruction services for arts, culture and technical skills	3,298.00	0.05%
679904	Miscellaneous repairs, n.e.c.	1,306.00	0.02%
679909	Miscellaneous personal services	6,416.00	0.09%

IO Code	Sector Clarification	Intermediate Input of Diesel consumption (x10^6 YEN)	Ratio
691100	Activities not elsewhere classified	106,130.00	1.50%
700000	Total of intermediate sectors	7,065,279.00	
721100	Consumption expenditure of households	660,103.00	
761101	Increase in producer's stocks of finished goods	8,562.00	
761102	Increase in semi-finished goods and work-in-progress	-5,434.00	
761103	Increase in dealer's stocks of goods	41,114.00	
761104	Increase in stocks of raw materials and supplies	-53,404.00	
771100		25,434.00	
780000	Total domestic final demand	676,375.00	
790000	Total domestic demand	7,741,654.00	
801101	Exports (ordinary trade)	1,090,646.00	
801102	Exports (special trade)	9,060.00	
801200	Exports (direct purchase)	8,272.00	
810000	Exports total	1,107,978.00	
820000	Total Final demand	1,784,353.00	
830000	Total demand	8,849,632.00	
841101	(less) Imports (ordinary trade)	-152,268.00	
841200	(less) Imports (direct purchase)	-6,249.00	
851100	(less) Custom duties	-1,530.00	
861100	(less) Commodity taxes on imported goods	-12,837.00	
870000	(less) Total imports	-172,884.00	
880000	Total of final demand sectors	1,611,469.00	
891100	Trade margins (wholesale)	-464,784.00	
891200	Trade margins (retail)	-457,092.00	
901100	Transportation charges (railway)	-7,522.00	
901200	Transportation charges (road)	-69,578.00	
901301	Transportation charges (coastal and inland water)	-20,528.00	
901302	Transportation charges (harbor)	-2,640.00	
901500	Transportation charges (forwarding)	-10,688.00	
901600	Transportation charges (storage facility)	-5,624.00	
970000	Domestic production (gross outputs)	7,638,292.00	
Grand Total		43,940,440.00	

Appendix B

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