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IDE DISCUSSION PAPER No.768

Mapping the Thai Automotive Value Chain with International Input-Output Data

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March 2020

Abstract

This study explores how the automotive value chain has evolved in Thailand since the 1990s. Trade in value added analysis is applied to international input-output data. Moreover, the method of value chain mapping is introduced to illustrate the upstream and downstream transactions of goods and services along the value chain. The results show that international linkages have been strengthened by the expansion of production networks in East Asia, whereas domestic linkages started to decline after 2000. In addition, the value chain mapping analysis indicates that the Thai automotive industry achieved high self-sufficiency in automotive inputs, but still depended heavily on imported basic metals.

Keywords: value chain mapping, trade in value added, automotive industry

JEL classification: D57, F14, O53

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1. Introduction¹

A country's participation in global value chains (GVCs) has become an increasingly important strategy for economic development. Unlike in the past, today's developing countries can take part in the GVCs of sophisticated products by specializing in a niche segment of a value chain. These developments are the result of the rapid decline in transportation and communication costs spurred by trade liberalization and technological development.

However, mere participation in GVCs is not sufficient. To sustain economic growth, there ought to be industrial deepening, which advances the formation of backward linkages by creating a robust supplier base (ADB, 2013). Industrial deepening is especially important for the automotive industry, which has strong agglomeration economies.

The advantages of industrial deepening or industrial agglomeration are manifold. First, industrial deepening increases the share of domestic value added in products and improves a country's balance of payments position. Second, the increase in assembler industries stimulates the development of upstream industries in sequence from parts and component suppliers to materials and machinery manufacturers through backward linkage effects (Hirschman, 1958), leading to the upgrading of the industrial structure. Finally, the development of supplier industries brings about other benefits of agglomeration such as forward linkage effects, which increase the competitiveness of downstream industries by delivering parts and components at lower cost, in less time, and with more flexibility.

On the contrary, the declining transportation and communication costs have increased the benefits of specialization and trade, reaping significant gains from the fragmentation of production processes across borders. For instance, as some production processes of automotive parts—notable examples are a wiring harness and an automotive seat cover—are labor intensive, it would be more efficient to relocate such production facilities to low-income countries.²

In summary, two forces work in opposing directions. The first one is the benefit of agglomeration,

which encourages local supplier development and strengthens domestic linkages. The second is the benefit of specialization and trade, which increases the share of foreign procurement and strengthens international linkages. It is therefore a matter of empirical evidence to demonstrate the types of linkages—domestic or foreign—that are strengthened during industrial development.

Against this background, the first aim of this study is to analyze the structural change in the Thai automotive value chain (including the formation of both domestic supplier bases and international production networks) and demonstrate which types of linkages—domestic or international—are strengthened during this process. The Thai automotive industry and its supplier bases have developed rapidly since the end of the 1980s. Concurrently, its value chain has increasingly become internationalized as a result of trade liberalization and regional integration efforts in East Asia since the early 1990s. In this paper, the method of trade in value added is employed to examine the structural change in input procurement and development of value chains since the 1990s.

Another aim of this study is to introduce the method of value chain mapping using international input-output data, which have recently been used to analyze the structure of vertical trade and decompose gross trade data (Hummels, Ishii, and Yi, 2001; Daudin, Riffart, and Schweisguth, 2011; Johnson and Noguera, 2012; Koopman, Wang, and Wei, 2014; Wang, Wei, Yu, and Zhu 2017). However, no attempts to use international input-output data for value chain mapping have thus far been made. Hence, adopting value chain mapping, which was first introduced by Kuroiwa (2016), fills this void in research and provides objective information on both the upstream and the downstream transactions of goods and services as well as primary inputs (value added) and final outputs (final demand) throughout the value chain.

Two sets of international input-output data—the Institute of Developing Economies (IDE-JETRO) Asian Input-Output (AIO) tables for 1990, 1995, 2000, and 2005 and the Organization for Economic Cooperation and Development (OECD) Inter-Country Input-Output (ICIO) tables for 2000

and 2011 (2016 edition)—are used to conduct the trade in value added and value chain mapping analyses.

The remainder of this paper is organized as follows. Section 2 outlines the development of the Thai automotive industry. Section 3 reviews the literature. Section 4 explains the value chain mapping and trade in value added analyses. Section 5 examines the empirical results. The paper concludes with a summary of the findings in Section 6.

2. Summary of the Thai automotive industry

The import substitution policy of the automotive industry was introduced in Thailand in the 1960s. Subsequently, it was extended to automotive parts and components, and the local content requirement (LCR) emerged because of the government's policy direction.

In the 1990s, the policy orientation changed dramatically. The import substitution policy was replaced by trade liberalization and export promotion; in 1991, the government allowed the importation of completely built vehicles with engines of less than 2300 cc and reduced the tariff on imported vehicles. In 1994, the government decided to grant a tax incentive to exporting firms in the industry.

Another turning point in the automotive industry policy direction came after the Asian financial crisis in 1997. To help local firms in financial distress, the government allowed a majority equity holding by foreign firms. In addition, it abolished the LCR in 2000 in accordance with the World Trade Organization's Agreement on Trade-Related Investment Measures.

- Figure 1 -

Figure 1 shows the domestic production of the Thai automotive industry during 1961–2014.

Thailand's automotive production started to increase rapidly at the end of the 1980s, although it plummeted temporarily during the periods of the Asian financial crisis (1997–1998), global financial crisis (2009), flooding (2011), and political conflict (2014).

Although exports of complete vehicles started in 1988, the Asian financial crisis triggered the rapid growth in vehicle exports. Consequently, the Thai automotive industry has become export-driven, with its share of exports exceeding 50 percent in recent years. It is particularly competitive in commercial vehicle exports, and Thailand has become known as the production hub of one-ton pickup trucks. In 2012, motor vehicle production reached 2.46 million units (with 1.02 million vehicles exported), making Thailand the ninth largest automotive manufacturer in the world.

In 2014, Japanese companies dominated the Thai automotive industry by accounting for 88.6 percent and 87.5 percent of Thailand's domestic production and domestic market, respectively. In particular, Toyota had a close to 40 percent share in both domestic production and market size (Fourin, 2015). As discussed later in the paper, such a market structure significantly affects the procurement of parts and components for the Thai automotive industry.

3. Literature review

Many studies have been conducted on the automotive industry in Thailand because of its success in the developing world. Although many developing countries have tried to create an automotive industry through protectionist measures, few have become internationally competitive. Relevant research work can be classified into several categories. Among them, industrial policy is one of the most controversial issues owing to its mixed findings. For example, Wad (2009) and Busser (2008) conclude that industrial policy did not play a decisive role in the growth in the Thai automotive industry, whereas Hassler (2009) and Rock (2001) show the positive value of industrial policy.

Such a difference is particularly significant when applied to the issue of the LCR. On the one hand,

Wad (2009), Athukorala and Kohpaiboon (2010), Warr and Kohpaiboon (2017) observe that the abolition of the LCR was a wholly positive aspect of economic liberalization, considering the heavy costs of the LCR on consumer welfare as well as investors' reluctance to invest when the requirement was in place. On the other hand, Hassler (2009) and Natsuda and Thoburn (2012) contend that the LCR provided a basis for the further localization of the Thai automotive industry, which actually took place after the 1990s (Baba, 2005).

The other factor affecting the localization of the automotive industry is the benefits of spatial agglomeration or formation of industrial clusters. Industrial clusters are formed by market externalities such as transportation cost savings, labor market pooling, and knowledge spillovers (Marshall, 1920; Fujita, Krugman, and Venables, 1999; Rosenthal and Strange, 2004; Fujita and Thisse, 2013). In particular, transportation cost and time savings—in tandem with savings in inventory costs that can be achieved by introducing a just-in-time production system—are among the most important forces causing the localization of automotive parts. This is particularly relevant for heavy and bulky parts such as body parts and other stamping parts, whose production facilities are often located close to assemblers. As a result, these agglomeration forces are likely to stimulate the local procurement of automotive parts and development of automotive clusters. In the Thai context, a number of researchers, including Lecler (2002), Poangsakorn and Techakanont (2008), and Kuroiwa, Techakanont, and Keola (2017), demonstrate that automotive clusters were initially formed in Bangkok and its vicinity and then extended to the Eastern Seaboard after the 1990s.

By contrast, the reduction in service link costs³ is a force driving production fragmentation or vertical specialization (VS). When service link costs are reduced sufficiently, a labor-intensive production block will be separated from other blocks and relocated to a less-developed country (Jones and Kierzkowski, 1990; Arndt and Kierzkowski, 2001). In particular, production fragmentation is strong in East Asia owing to the existence of a large number of countries at different income levels

(Kimura and Ando, 2003).

As for the geographical sphere of automotive value chains, Dicken (2007) observes that rather than organizing operations on a global scale, leading automotive producers aim to create distinct production and marketing networks within Europe, North America, and East Asia. More specifically, Lall (2003) contends that production fragmentation is strong in the automotive sector,⁴ but the weight of the product and its high basic capability requirements mean that it only extends to a few proximate, relatively industrialized locations.

Indeed, Thailand has traditionally been highly dependent on Japan for automotive parts and components, but Japan's share has been taken by neighboring East Asian countries such as ASEAN nations and China (Athukorala and Kohpaiboon, 2010; Warr and Kohpaiboon, 2017). At the same time, ASEAN countries and Australia have become an important market for the Thai automotive industry owing to the progress made by the ASEAN Free Trade Area and Thailand–Australia FTA, respectively (Kohpaiboon and Yamashita, 2011). In sum, the Thai automotive value chain has been increasingly regionalized owing to greater economic integration and rapid industrial development in East Asia.

4. Method

This study adopts two methods of input-output analysis: value chain mapping and the VS share and its decomposition method.

4.1 Value chain mapping

Value chain mapping, using international input-output data, was first introduced by Kuroiwa (2016). It demonstrates both the upstream and the downstream transactions of intermediate goods and services as well as value added (primary inputs) and final demand (final outputs). Moreover, unlike conventional value chain analysis, it covers direct (i.e., first-order) repercussion effects not only on

automotive parts⁵ but also on other intermediate goods and services such as machinery parts, metal products, and rubber and plastics products as well as trade, transport, and financial services. Further, value chain mapping captures the indirect (i.e., secondary or higher-order) repercussion effects on entire upstream industries, which may include basic metals, chemicals, minerals, and crude petroleum.

(1) Upstream transactions

Using the conventional mathematical expression for the Leontief (demand-side) model, upstream transactions associated with one unit of final demand for a specific sector—say, sector j in country s —can be obtained by post-multiplying the input coefficient matrix \mathbf{A} by the diagonal matrix $\hat{\mathbf{L}}_{(j)}^{(s)}$:

$$\mathbf{U}_{(j)}^{(s)} = \mathbf{A}\hat{\mathbf{L}}_{(j)}^{(s)}, \quad (1)$$

where $\hat{\mathbf{L}}_{(j)}^{(s)}$ is the diagonal matrix of $\mathbf{l}_{(j)}^{(s)}$, which represents the column vector of the Leontief inverse matrix and output of all sectors in all countries, induced by one unit of final demand for sector j in country s .

Similarly, induced value added—the remuneration paid for primary inputs such as labor compensation, profits, and indirect taxes—is calculated by post-multiplying the row vector of the value added coefficients (i.e., value added to output ratios) by $\hat{\mathbf{L}}_{(j)}^{(s)}$:

$$\mathbf{v}_{(j)}^{(s)'} = \mathbf{v}(\mathbf{c})'\hat{\mathbf{L}}_{(j)}^{(s)}, \quad (2)$$

where $\mathbf{v}(\mathbf{c})'$ is the row vector of the value added coefficients for all sectors in all countries.

Equations (1) and (2) represent upstream intermediate transactions and value added (primary inputs), respectively, which are associated with one unit of motor vehicles, when sector j is designated as the motor vehicle sector in a country.

(2) Downstream transactions

Using the mathematical expression for the Ghosh (supply-side) model,⁶ downstream transactions

associated with one unit of primary inputs for sector i in country r can be given by pre-multiplying the output coefficient matrix \mathbf{B} by the diagonal matrix $\widehat{\mathbf{G}}_{(i)}^{(r)}$:

$$\mathbf{D}_{(i)}^{(r)} = \widehat{\mathbf{G}}_{(i)}^{(r)} \mathbf{B}, \quad (3)$$

where $\widehat{\mathbf{G}}_{(i)}^{(r)}$ is the diagonal matrix of $\mathbf{g}_{(i)}^{(r)}$, which represents the row vector of the Ghosh inverse matrix (Ghosh, 1958) and indicates the output of all sectors in all countries induced by one unit of primary inputs for sector i in country r . As shown below, the Ghosh model in which downstream transactions are stimulated by upstream transactions is associated with forward linkages, whereas the Leontief model, which has the opposite transmission mechanism, is associated with backward linkages (Miller and Blair, 2009).

Final output (for household consumption, gross fixed capital formation, etc.) associated with one unit of primary inputs for sector i in country r is calculated as

$$\mathbf{F}_{(i)}^{(r)} = \widehat{\mathbf{G}}_{(i)}^{(r)} \mathbf{F}(\mathbf{c}), \quad (4)$$

where $\mathbf{F}(\mathbf{c})$ is the matrix of the final demand coefficients (i.e., final demand to total output ratio). Equation (3) and Equation (4) represent the downstream intermediate transactions and final demand (final outputs), respectively, which are associated with one unit of motor vehicles when sector i is designated as the motor vehicle sector.

4.2 VS share and its decomposition method

The VS share represents the percentage share of foreign content embodied in exports (i.e., the share of value added induced by exports but that accrues to foreign countries). Therefore, the VS share indicates the true dependency on foreign inputs.⁷ The VS share of sector j in country s —equivalent to Equation (40) in Koopmans, Wang, and Wei (2014)—can be expressed as

$$VS_{(j)}^{(s)} \text{ share} = 100 \times \sum_{r \neq s}^m \sum_{i=1}^n \mathbf{v}(\mathbf{c})_i^r \mathbf{L}_{(j)i}^{(s)r} = 100 \times \sum_{r \neq s}^m \sum_{i=1}^n \mathbf{v}_{(j)i}^{(s)r}, \quad (5)$$

where $\mathbf{v}(\mathbf{c})_i^r$ is the value added coefficient of sector i in country r and $\mathbf{L}_{(j)i}^{(s)r}$ is an element in the

Leontief inverse matrix that represents the output of sector i in country r induced by one unit of export demand for sector j in country s . Thus, $\mathbf{v}_{(j)i}^{(s)r}$ indicates the value added (in sector i in country r) induced by export demand (for sector j in country s). The VS share is closely related to upstream transactions under value chain mapping. Indeed, the VS share can be calculated by aggregating the induced foreign value added obtained from Equation (2) across countries and sectors. Therefore, as in value chain mapping, the VS share captures both the direct and the indirect repercussion effects on overseas industries.

Moreover, the $VS_{(j)}^{(s)}$ share can be decomposed as follows:

(i) The share of foreign content by country of origin (r) is calculated by

$$VS_{f_{(j)}^{(s)r}} \text{ share} = 100 \times \sum_{i=1}^n \mathbf{v}_{(j)i}^{(s)r}, \quad (6)$$

where, if $r=s$ in Equation (6), the above index represents the share of domestic content.

(ii) The share of foreign content by industry of origin (i) is given by

$$VS_{f_{(j)i}^{(s)}} \text{ share} = 100 \times \sum_{r \neq s}^m \mathbf{v}_{(j)i}^{(s)r}. \quad (7)$$

In sum, the $VS_{f_{(j)}^{(s)r}}$ share and $VS_{f_{(j)i}^{(s)}}$ share can be derived from Equation (5) by aggregating $\mathbf{v}_{(j)i}^{(s)r}$ across industries and countries, respectively.

5. Empirical results

This section examines first the procurement of intermediate inputs by the Thai automotive industry during 1990–2011 and then the results of the analyses for VS share and value chain mapping.

5.1. Procurement of intermediate inputs (1990–2011)

Using the AIO tables for 1990, 1995, 2000, and 2005 and ICIO tables for 2011 (2016 edition), Figure 2 indicates the percentage shares of all intermediate inputs; these include not only automotive parts and components, but also other parts, materials, and services used by the Thai automotive industry.

Figure 2 shows that the share of domestic procurement increased from 32.6 percent to 45.2 percent during 1990–2000⁸ but declined slightly to 44.6 percent in 2005. The declining trend continued until 2011. The share of domestic procurement continued to rise until the LCR was abolished in 2000.

— Figure 2 —

The share of procurement from ASEAN countries continued to rise from less than 2 percent to more than 5 percent during 1990–2005, while the share of Japan as well as the rest of the world (ROW) declined substantially. However, the share of the ROW, which includes China, increased in 2011. Among the factors that affected the shift in source countries (i.e., the increasing trend of domestic procurement until 2000 and that of foreign procurement after 2000), the following factors appear to be important.

(1) LCR

After the LCR was introduced in 1975, the level of local content imposed by the government continued to increase until the end of the 1980s. The high-level LCR continued until it was abolished in 2000. More specifically, the LCR was gradually increased from 25 percent for passenger cars in 1975 to 54 percent in 1990; the LCRs for petrol-fueled and diesel-fueled pick-up trucks were raised to 60 percent and 72 percent, respectively (Wattanasiritham, 2000).

The LCR policy raised the costs of automotive parts and thus negatively affected the efficiency of motor vehicle production.⁹ However, despite these costs, it helped engage local and foreign suppliers in the supply chain and increased the share of domestic procurement.¹⁰ For example, Table 1 shows that the number of Thai firms established in the respective periods outnumbered foreign firms and joint ventures and that they grew substantially during 1986–1999. Moreover, many foreign parts

suppliers, particularly Japanese suppliers, made investments to comply with assemblers requests. Table 1 shows that the number of Japanese investments started to increase rapidly in the mid-1980s.

— Table 1 —

Table 2 reveals that the types of parts produced in Thailand also increased in the same period. In particular, the number of technologically sophisticated parts such as engine parts grew substantially owing to the LCR that was specifically imposed on engine parts during 1989–1998; engine manufacturers had to increase local content every year, from 20 percent in 1989 to 70 percent in 1998.¹¹

By contrast, Warr and Kohpaiboon (2017) contend that manufacturers are strongly averse to restrictions on their input procurement decisions. Hence, the abolishment of the LCR attracted more investment and thus helped raise local content. Warr and Kohpaiboon (2017) show that the value of imported parts per locally assembled vehicle continued to decrease even after 2000 (although only until 2005), a result that partially conflicts with that shown in Figure 1.¹²

As discussed below (see also Warr and Kohpaiboon, 2017), agglomeration economies induce higher local content without policy intervention. Thus, policy intervention such as the LCR becomes unnecessary once the critical mass of industrial agglomeration is established. However, whether the critical mass can be achieved without policy intervention remains an open question.

— Table 2 —

(2) Local procurement and forward linkage effects

Sales competition has become tougher since the automotive industry was liberalized through the

import liberalization of completely built vehicles, tariff reductions, and removal of barriers to market entry in the early 1990s. Since then, automotive assemblers have been forced to reduce production costs and increase competitiveness in the market. Since many automotive parts and components are heavy and bulky, the option of procuring them locally would reduce transportation and logistics costs and enhance the competitiveness of assemblers; this agglomeration effect, called the forward linkage effect, is expected to attract more assemblers to the host country (Fujita, Krugman, and Venables, 1999). In addition, local procurement facilitates just-in-time production and delivery, which lowers inventory costs.¹³ Thus, assemblers have strong incentives to request parts suppliers to be located in their vicinity.

(3) Growth in vehicle production and backward linkage effects

Owing to scale economies, there is a certain threshold production volume at which the costs of procuring parts and components locally become lower than those of procuring them from the international market. When this occurs, rapid growth in motor vehicle production would induce the establishment of local suppliers and increase domestic procurement; this agglomeration effect (i.e., backward linkage effect) is expected to tempt more parts suppliers to the host country. As Figure 1 shows, Thai vehicle production volume has grown rapidly since the end of the 1980s, accompanied by a significant rise in the number of automotive parts suppliers (Tables 1 and 2).

(4) Formation of automotive production networks in East Asia

The above three factors contributed to increasing the domestic procurement of automotive parts. However, as shown in Figure 2, the share of domestic procurement started to decline after 2000. At this turning point around 2000, the benefits of specialization and trade, including those associated with trade in parts and components in the region, became greater than the benefits of agglomeration:

moreover, automotive exports, which have increased dramatically since the end of the 1990s, may have raised demand for imported inputs because international markets require higher product quality. As a result, production networks started to expand rapidly across national boundaries and international linkages strengthened, especially with neighboring countries in East Asia. In the next subsection, we focus on the structural change that occurred in 2000–2011 when the share of domestic procurement started to decline as a result of expanding production networks.

5.2. VS structure (2000–2011)

In this subsection, the OECD ICIO tables for 2000 and 2011 (2016 edition) are used to calculate the VS share and examine the development of cross-border production networks.

(1) VS share

Table 3 shows the VS share of the automotive industry in 16 countries or regions, which are regroupings of the 62 countries or regions covered in the original ICIO tables. As in many other countries (with the exception of the Philippines and Indonesia), the VS share of the Thai automotive industry increased from 51.5 percent to 56.5 percent during 2000–2011. This implies that as the Thai automotive industry became more integrated into GVCs, its dependency on foreign content increased, consistent with the declining domestic procurement after 2000 shown in Figure 2.

— Table 3 —

ASEAN countries such as Malaysia, Thailand, and Vietnam had relatively high VS shares, exceeding 50 percent in 2011. Canada and Mexico—members of the North American Free Trade Agreement—also had high VS shares. These facts suggest that small and open economies actively

involved in production networks tend to have high VS shares. By contrast, larger economies such as Japan, the European Union (EU), and China had relatively low VS shares, whereas the United States, which is closely integrated with the North American automotive value chain, was the notable exception.

In sum, although the automotive industry has strong agglomeration economies, the benefits of specialization and trade have gained ascendancy over the benefits of agglomeration owing to trade liberalization and economic integration. In this regard, the geographical spread of automotive value chains, as demonstrated by the increasing VS, is not unique to East Asia. In the next section, the VS share of Thai automotive exports is subdivided into its constituent elements.

(2) Decomposition of the VS share

Table 4 shows the share of foreign content in Thai automotive exports by country of origin (Equation (6)). Japan's content was the largest among all countries, reflecting the fact that the Thai automotive industry has been dominated by Japanese companies. However, Japan's share declined sharply from 21.9 percent to 14.9 percent during 2000–2011. Other developed countries/regions such as the EU and the United States have also seen a substantial decline in their shares.

— Table 4 —

East Asian countries, on the contrary, demonstrate the opposite trend. In particular, Southeast Asian countries and China have increased their shares; the share of ASEAN countries as a whole rose from 4.7 percent to 6.2 percent during 2000–2011 and that of China increased from 1.7 percent to 6.5 percent. Moreover, the shares of Korea, India and Mexico as well as Australia and Canada have also increased. Hence, the shift in sourcing intermediate inputs from Japan and other developed countries to neighboring East Asian (i.e., Northeast Asian and Southeast Asian) nations and emerging

automotive manufacturing countries has been drastic.

Table 5 presents the share of foreign content, by industry of origin, in Thai automotive exports (Equation (7)). Wholesale and retail trade had the highest share (10.2 percent in 2000 and 2011). Other services such as transportation, financial intermediation, research and development, and other business activities also had higher foreign than domestic content shares. These results suggest that a great amount of service content was imported to produce automotive exports.¹⁴ Service content rises further when measured in value added terms because a variety of services are used as inputs for manufactured goods and thus a substantial amount of service content is imported indirectly through manufacturing trade.

— Table 5 —

The shares of both basic metals and mining¹⁵ are significantly high. Moreover, they increased rapidly and even exceeded 8 percent in 2011. There was higher dependency on importing basic metals owing to the weak production capacity of the basic metals industry, whose domestic content was less than 1 percent. Similarly, other material industries such as chemicals, rubber and plastics, and fabricated metal products also had high foreign content shares. This finding implies that the actual dependency on domestic inputs (i.e., domestic content) was significantly lower than the nominal local content, which is calculated based on assemblers' domestic sourcing of intermediate inputs, because a large proportion of value added leaked out of the country in the upstream production process.

By contrast, the domestic content share of the motor vehicle sector exceeded 25 percent, while its foreign content share decreased to only 3.5 percent in 2011. This reflects a remarkable achievement in the localization efforts for parts and components. Similarly, machinery and equipment achieved a relatively high domestic content share (3.6 percent in 2000 and 2.2 percent in 2011), whereas other

machinery industries such as computer, electronic and optical equipment, and electrical machinery still had low shares.

5.3. Mapping the automotive value chain (2000–2011)

The separate decomposition of the VS share shows how much value added is generated by country of origin (Table 4) and sector of origin (Table 5). Value chain mapping, on the contrary, combines this information to demonstrate how much value added as well as intermediate transactions are generated in a specific country-sector pair throughout the value chain.

(1) Upstream transactions

Figures 3a and 3b show the upstream intermediate transactions of goods and services as well as value added associated with one unit of motor vehicle demand in Thailand (Equations (1) and (2)). Here, one unit is normalized to 100 units, and thus only induced intermediate transactions and value added that exceed one unit (i.e., 1 percent of original motor vehicle demand) are shown in the figure.¹⁶

— Figures 3a and 3b —

Figure 3a shows that in 2000, 27.1 units of Thai motor vehicle outputs were used as inputs for its own industry. Simultaneously, motor vehicle outputs were provided by Japan (9.5 units), the EU (2.3 units), and the Philippines (1.2 units). In addition, machinery and equipment, basic metals, and rubber and plastic products constitute major inputs for the motor vehicle sector. Service inputs such as wholesale and retail trade, transportation, and electricity, gas, and water supply also occupy a high share. As a result, high value added was generated in such sectors as motor vehicles (25.5 units), wholesale and retail trade (5.1 units), and machinery and equipment (3.6 units).

Foreign inputs were highly concentrated on Japan; in particular, they were high in motor vehicles, wholesale and retail trade, basic metals, and machinery and equipment, reflecting the fact that the Thai automotive industry has been dominated by Japanese firms. In addition, the motor vehicle sector exceeded 1 percent in the EU and the Philippines, while basic metals did so in the ROW. In 2011, source countries of intermediate inputs became more diversified. In addition to Japan and the ROW, China, Korea, and Australia became major suppliers of basic metals. At the same time, backward linkages with Japanese industries weakened significantly, as they were replaced by those in neighboring East Asian countries.

(2) Downstream transactions

Because the motor vehicle industry—more specifically, assembling motor vehicles—is close to the final market, downstream intermediate transactions of motor vehicles are expected to be relatively rare. However, its parts and components, which constitute an important part of the motor vehicle industry, are used as inputs for its own industry. In addition, other industries such as trade and transportation may use them actively in their operations.

Figures 4a and 4b show the downstream intermediate transactions of goods and services as well as those of final outputs; these are associated with 100 units of motor vehicle primary inputs (value added) in Thailand (Equations (3) and (4)).

— Figures 4a and 4b —

Figure 4a shows that, in 2000, 27.1 units of motor vehicle outputs were used as inputs for its own industry, whereas the largest domestic transactions were in gross fixed capital formation (28.3 units)¹⁷

and household consumption (14.9 units). In foreign markets, motor vehicle outputs were used as inputs and distributed to the motor vehicle industry in the EU (4.9 units), Japan (2.9 units), Australia (1.2 units), and the ROW (1.1 units). However, a greater proportion was destined for capital formation and household consumption in the EU (5.1 units and 7.9 units, respectively), Japan (1.1 units and 1.6 units), Australia (1.9 units and 2.8 units), the United States (1.1 units for household consumption), and the ROW (3.0 units and 2.2 units). In addition, some foreign final outputs were induced indirectly through intermediate transactions; for example, 4.9 units of motor vehicle outputs were induced in the EU by inputs from the Thai motor vehicle industry and the EU motor vehicle industry induced 1.3 units of motor vehicle outputs for capital formation and 2.2 units for household consumption in the EU.

In 2011, countries closely linked to the Thai motor vehicle industry changed substantially. In particular, the Thai motor vehicle industry provided inputs and strengthened forward linkages with neighboring Southeast Asian countries such as Indonesia and Malaysia; simultaneously, in addition to the Philippines and Australia, they have become an important market for the complete motor vehicles assembled in Thailand. The ASEAN Free Trade Area and other regional integration efforts, such as the ASEAN-Australia-New Zealand FTA, have facilitated trade not only in parts and components but also in complete motor vehicles in these countries. On the contrary, linkages with Japanese and EU industries have substantially weakened, as shown in Figure 4b.

6. Conclusion

In the Thai automotive industry, the share of the domestic procurement of intermediate inputs continued to rise during 1990–2000 but declined during 2000–2011. Moreover, our trade in value added analysis demonstrates that the foreign content of Thai automotive exports increased in the latter period. These results suggest that the dependency on domestic procurement initially increased but started to decline after around 2000.

Although a more detailed analysis is necessary, the abolition of the LCR in 2000 as well as trade liberalization and regional integration efforts since the early 1990s appear to have affected the trend of sourcing intermediate inputs. As a result, although the automotive industry has strong agglomeration economies, the benefits from specialization and trade have gained ascendancy over those from agglomeration and thus international linkages have strengthened, especially with neighboring East Asian countries.

The decomposition analysis of foreign content shows that Japan had the largest foreign content share, but that its share declined significantly during 2000–2011. By contrast, the shares of Southeast Asian countries and China increased substantially owing to the economic integration and rapid industrial development in these countries. It also shows that a large amount of service content was imported to produce automotive exports because services are used as inputs for manufactured goods; thus, a substantial amount of service content is imported indirectly through manufacturing trade. In the manufacturing sector, Thailand had higher dependency on the import of basic metals owing to the weak production capacity of the domestic basic metals industry.

Other material industries such as chemicals, rubber and plastics, and fabricated metal products also had high foreign content shares, suggesting that the actual dependency on domestic inputs was significantly lower than the nominal local content indicates because a large proportion of value added leaked out of the country in upstream production processes. On the contrary, the motor vehicle industry had a strikingly high domestic content.

The value chain mapping analysis also shows that the Thai motor vehicle industry achieved high self-sufficiency in its parts and components but had high dependency on basic metals imported from Japan, China, Korea, and Australia. Downstream intermediate transactions in the motor vehicle sector are relatively scarce, but a proportion of motor vehicle outputs was used as inputs for its own industry, whereas a greater proportion was used either for fixed capital formation or household consumption in

both domestic and foreign markets. In particular, the Thai motor vehicle industry strengthened linkages with neighboring Southeast Asian countries and Australia, where the ASEAN Free Trade Area and other regional integration efforts facilitated trade not only in parts and components but also in complete motor vehicles.

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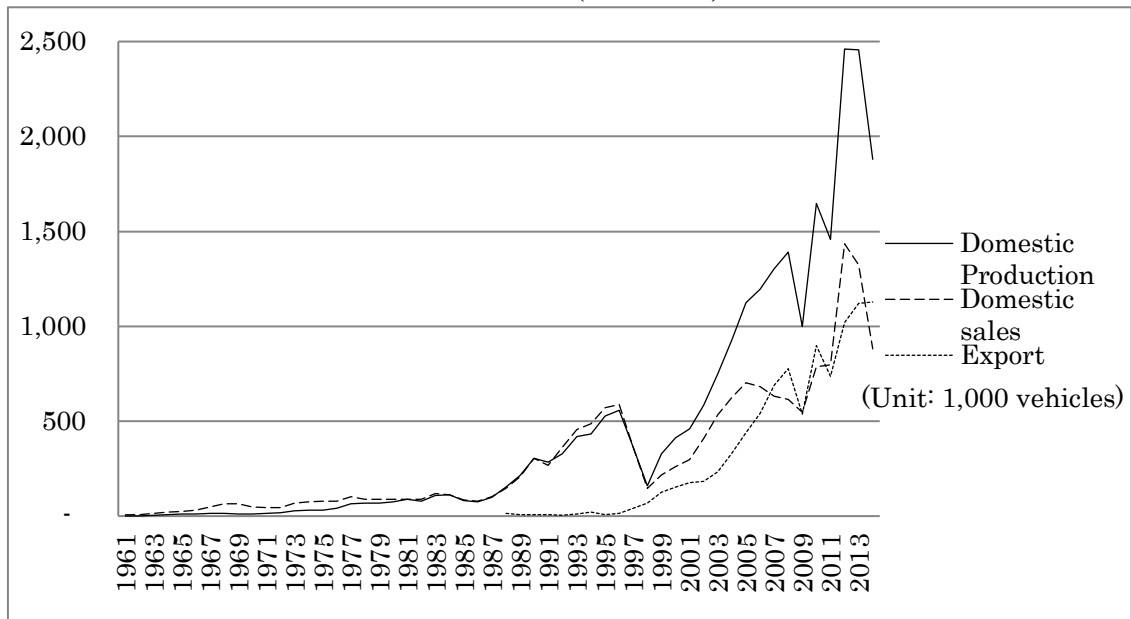
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Appendix: Sector Classification of the OECD ICIO Tables

AGR	Agriculture, hunting, forestry, and fishing
MIN	Mining and quarrying
FOD	Food products, beverages, and tobacco
TEX	Textiles, textile products, leather, and footwear
WOD	Wood and products of wood, and cork
PAP	Pulp, paper, paper products, printing, and publishing
PET	Coke, refined petroleum products, and nuclear fuel
CHN	Chemicals and chemical products
RBP	Rubber and plastics products
NMM	Other non-metallic mineral products
MET	Basic metals
FBM	Fabricated metal products
MEQ	Machinery and equipment, nec
CEO	Computer, electronic, and optical equipment
ELQ	Electrical machinery and apparatus, nec
MTR	Motor vehicles, trailers, and semi-trailers
TRQ	Other transport equipment
OTM	Manufacturing nec; recycling
EGW	Electricity, gas, and water supply
CON	Construction
WRT	Wholesale and retail trade; repairs
HTR	Hotels and restaurants
TRN	Transport and storage
PTL	Post and telecommunications
FIN	Financial intermediation
REA	Real estate activities
RMQ	Renting of machinery and equipment
ITS	Computer and related activities
BZS	Research and development and other business activities
GOV	Public admin. and defense; compulsory social security
EDU	Education
HTH	Health and social work
OTS	Other community, social, and personal services
PVH	Private households with employed people
HC	Household consumption
NPI	Non-profit institution serving household
GGF	General government final consumption
GFC	Gross fixed capital formation
INV	Changes in inventories
CON	Direct purchase abroad by residents
DISC	Discrepancies
VA	Value added
CT	Output at basic prices

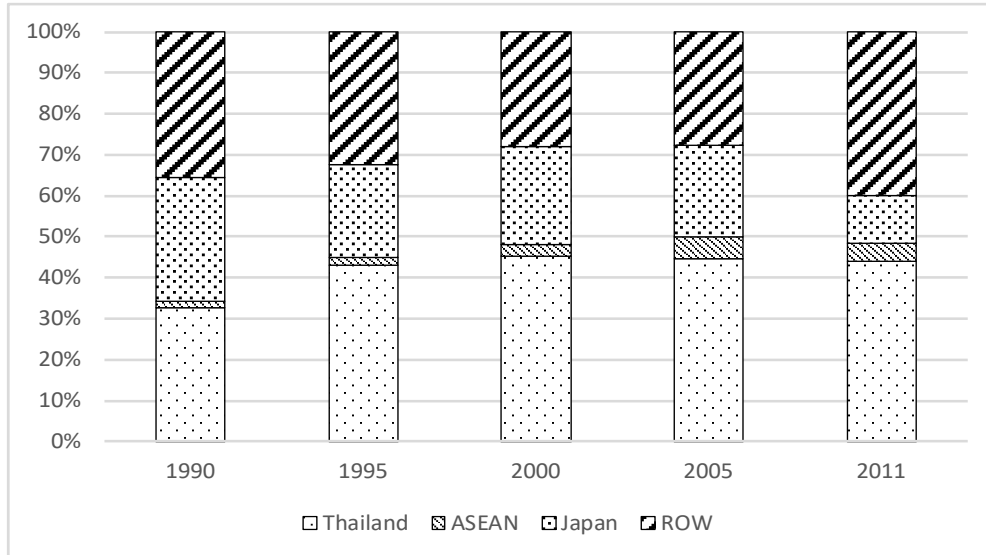
Source: ICIO tables (OECD).

Figure 1. Domestic Production, Domestic Sales, and Exports of Automobiles in Thailand (1961–2014)



Source: Author's calculation based on data from the Thailand Automotive Club, Federation of Thai Industries.

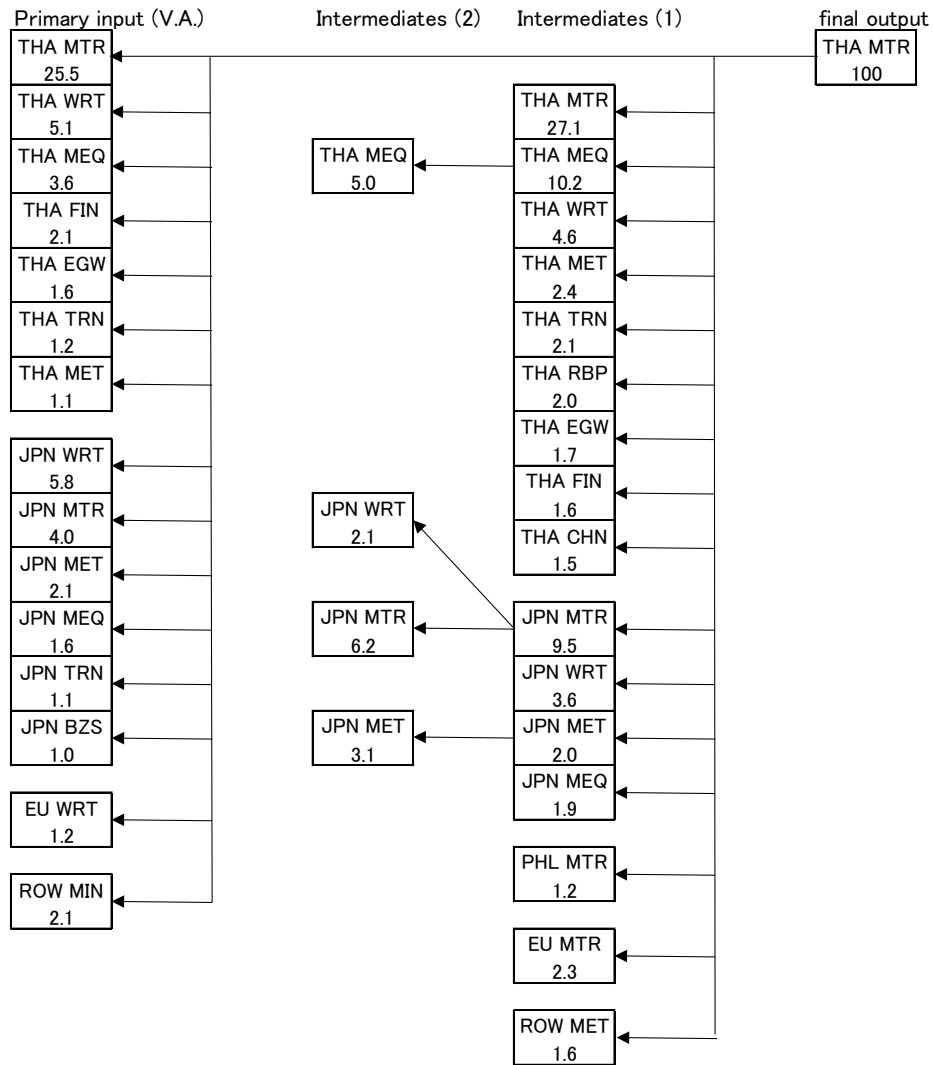
Figure 2. Procurement of Intermediate Inputs by Country or Region: Motor Vehicle Sector in Thailand (1990–2011)



Source: Calculated from the Asian input-output tables for 1990, 1995, 2000, and 2005 (IDE-JETRO) and from the ICIO table for 2011 (2016 edition, OECD).

Note 1: The bars show the percentage shares of intermediate inputs provided by respective countries or regions. In the Asian tables, ASEAN includes Indonesia, Malaysia, Singapore, and the Philippines.
 Note 2: Care should be taken when comparing the results for 1990–2005 with those for 2011 because different international input-output data are used for the calculation.

Figure 3a. Flow of Upstream Transactions: Motor Vehicle Sector in Thailand (2000)

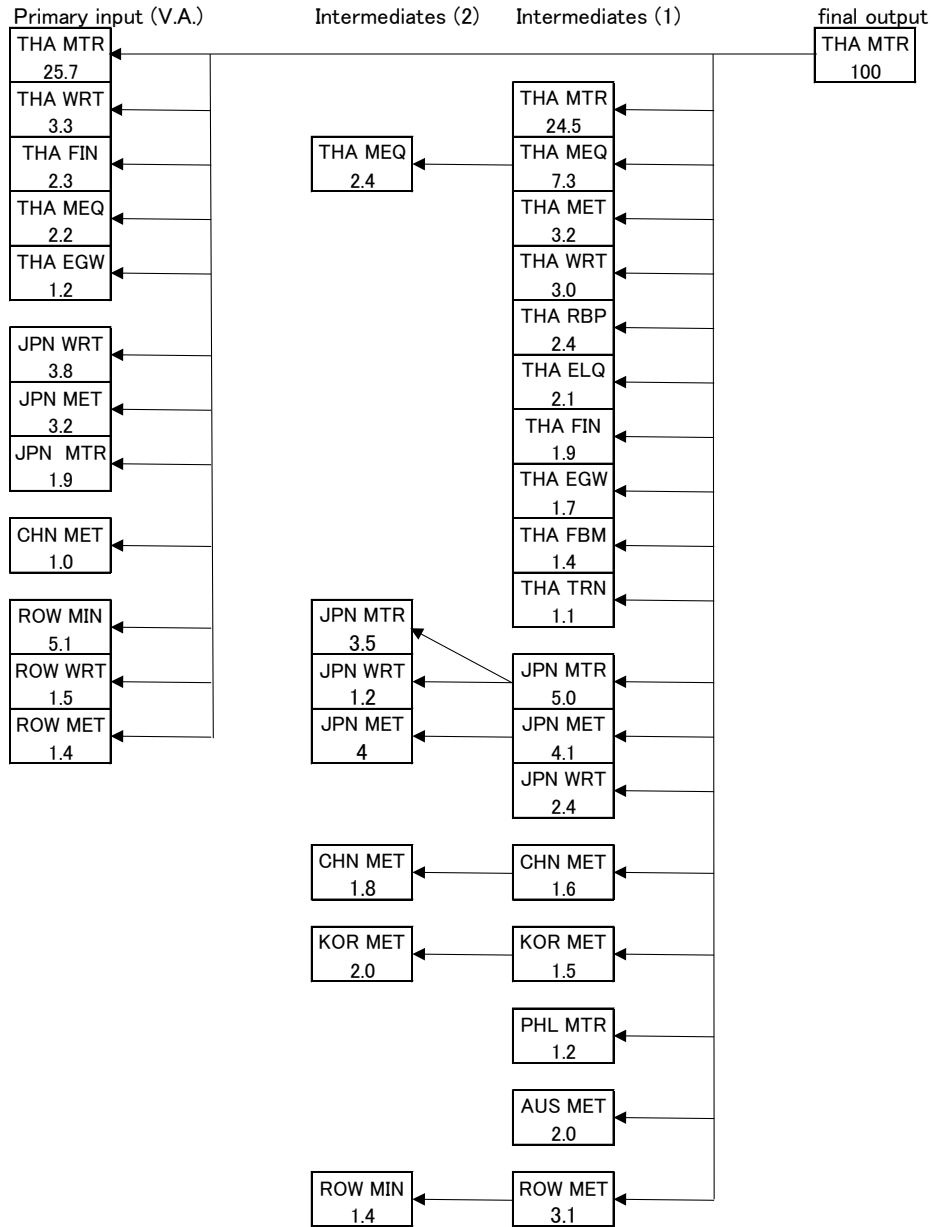


Source: Calculated from the ICIO table for 2000 (OECD).

Note 1: For the sector classification, see the Appendix.

Note 2: Arrows show the direction of the repercussion effects, and these are drawn based on the input-output relationship calculated from Equations (1) and (2).

Figure 3b. Flow of Upstream Transactions: Motor Vehicle Sector in Thailand (2011)

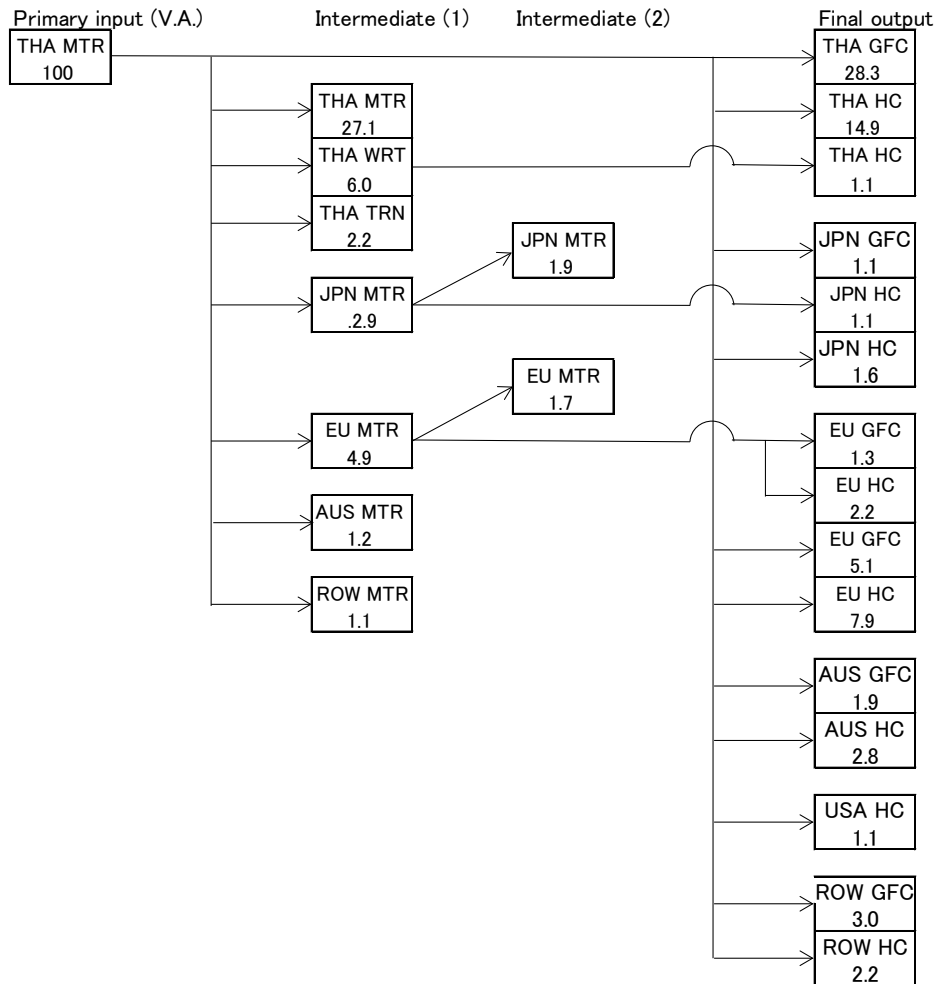


Source: Calculated from the ICIO tables for 2011 (OECD).

Note 1: For the sector classification, see the Appendix.

Note 2: Arrows show the direction of the repercussion effects, and these are drawn based on the input-output relationship calculated from Equations (1) and (2).

Figure 4a. Flow of Downstream Transactions: Motor Vehicle Sector in Thailand (2000)

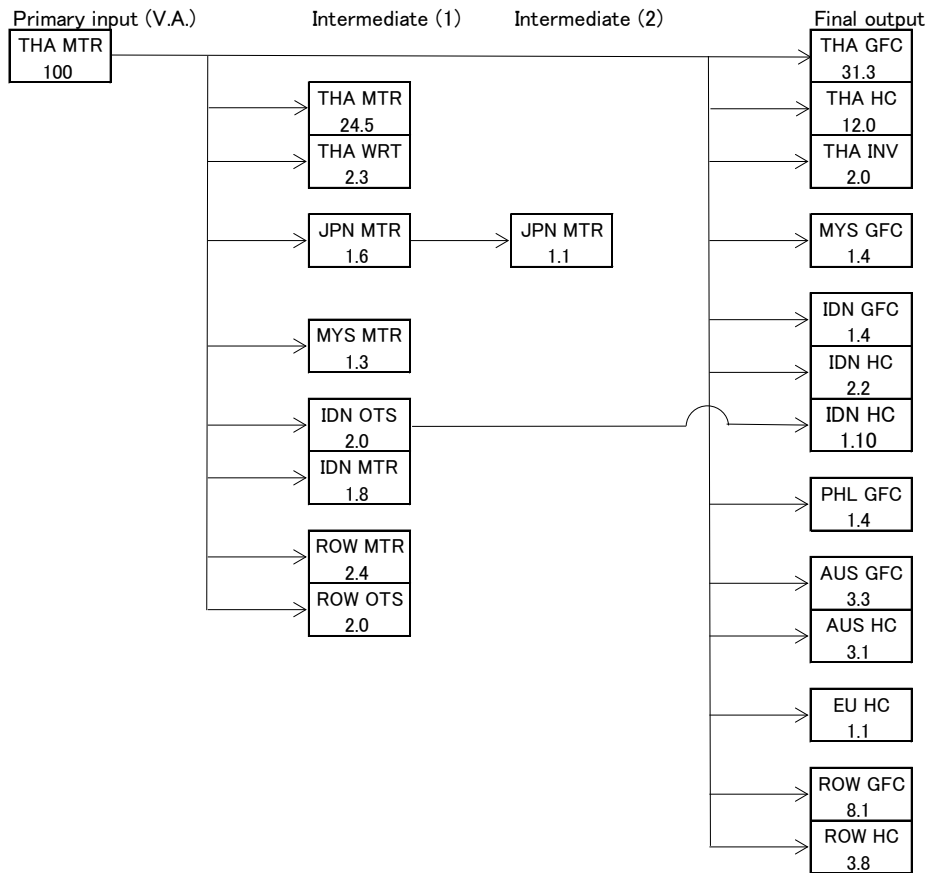


Source: Calculated from the ICIO tables for 2000 (OECD).

Note 1 : For the sector classification, see the Appendix.

Note 2: Arrows show the direction of the repercussion effects, and these are drawn based on the input-output relationship calculated from Equations (3) and (4).

Figure 4b. Flow of Downstream Transactions: Motor Vehicle Sector in Thailand (2011)



Source: Calculated from the ICIO tables for 2011 (OECD).

Note 1 : For the sector classification, see the Appendix.

Note 2: Arrows show the direction of the repercussion effects, and these are drawn based on the input-output relationship calculated from Equations (3) and (4).

**Table 1. Ownership Types by Periods of Establishment: Thai
Automotive Industry**

	-1960	1961-75	1976-85	1986-99	2000-14
Thai firms	8	69	97	297	102
Foreign firms	0	14	6	163	55
(Japanese firms)	0	9	4	115	33
Joint Venture	4	22	18	123	35
Unknown	11	56	71	302	197
Total	23	161	192	885	389

Source: Calculated from the Thailand Automotive Industry Directory 2014.

Table 2. Types of Parts by Periods of Establishment: Thai Automotive Industry

	-1960	1961-75	1976-85	1986-99	2000-14
Engine	9	58	51	253	89
Drive train	1	7	11	52	29
Suspension / steering / wheel & tire	4	22	40	110	48
Axle/brake/body control,	1	19	28	125	53
Body and exterior	4	35	47	170	78
Interior	1	15	23	94	49
Climate control	3	11	22	68	25
Driving support & security	0	2	6	22	7
Electronic/electrical parts	1	11	17	95	26
Small/general parts	4	39	52	199	77
Categories by production process	3	41	61	260	124
Motorcycle parts	5	44	67	263	94
Automobile assembly	4	8	1	18	9
Agricultural machinery and other transport machinery	3	16	22	44	29
Chemical, oil, lubricant, paint, etc.	2	18	17	61	25
Accessories	0	13	16	61	28
Service (trading, logistics, trade show, training, etc.)	6	35	32	154	107
Machine tools, jigs and fixtures, moulds and dies, etc.	1	9	19	68	36
TOTAL	52	403	532	2117	933

Source: Calculated from the Thailand Automotive Industry Directory 2014.

Note 1. Parts of other transport machinery such as motorcycles and agricultural machinery are included in the data.

Note 2. The number of types of parts is greater than the number of establishments because each establishment (or plant) may produce more than one type of part.

Table 3. VS (Foreign Content) Share: Motor Vehicle Sector in 16 Countries or Regions (2000, 2011)

	VS share (2000)	VS share (2011)
China	18.1	22.6
Japan	7.9	14.0
Korea	28.8	37.8
Taiwan	31.7	47.8
Malaysia	50.2	59.1
Philippines	41.4	40.3
Indonesia	32.1	25.5
Thailand	51.5	56.5
Vietnam	38.3	55.1
India	18.0	32.5
Australia	23.8	25.2
USA	24.4	35.6
Canada	51.7	59.4
Mexico	40.2	45.0
EU	12.4	16.2
ROW	21.1	24.8

Source: Calculated from the ICIO tables for 2000 and 2011 (OECD).

Note: The original OECD ICIO table contains 62 countries or regions, but these are aggregated into 21 countries or regions for this study; of these 21, only 16 have a motor vehicle assembly industry.

Table 4. Decomposition of the VS (Foreign Content) Share by Country of Origin: Motor Vehicle Sector in Thailand (2000, 2011)

	VS share (2000)	VS share (2011)
Foreign content	51.5	56.5
China	1.7	6.5
Japan	21.9	14.9
Korea	1.4	2.2
Taiwan	1.4	1.1
Hong Kong	0.5	0.3
Singapore	1.3	0.9
Malaysia	1.2	1.3
Brunei Darussalam	0.1	0.1
Philippines	1.0	1.2
Indonesia	0.7	2.3
Vietnam	0.3	0.3
Cambodia	0.0	0.0
(ASEAN)	4.7	6.2
India	0.4	1.0
Australia	1.3	3.1
New Zealand	0.1	0.1
USA	3.7	2.9
Canada	0.3	0.5
Mexico	0.2	0.4
EU	8.0	6.2
ROW	6.2	11.1
Domestic content	48.5	43.5
Total content	100	100

Source: Calculated from the ICIO tables for 2000 and 2011 (OECD).

Note: ASEAN includes Singapore, Malaysia, Brunei Darussalam, the Philippines, Indonesia, Vietnam, and Cambodia.

Table 5. Decomposition of the VS (Foreign Content) and Domestic Content Shares by Industry of Origin: Motor Vehicle Sector in Thailand (2000, 2011)

	2000			2011		
	Domestic content	Foreign content	Total content	Domestic content	Foreign content	Total content
AGR	0.6	0.4	1.0	0.7	0.6	1.3
MIN	0.7	3.2	3.9	0.7	8.2	9.0
FOD	0.1	0.2	0.3	0.1	0.2	0.3
TEX	0.4	0.2	0.6	0.3	0.2	0.5
WOD	0.1	0.1	0.2	0.2	0.2	0.3
PAP	0.2	0.8	1.0	0.1	0.6	0.6
PET	0.5	0.6	1.0	0.3	0.8	1.1
CHM	0.7	2.0	2.7	0.4	1.7	2.1
RBP	0.6	1.5	2.2	0.6	1.1	1.7
NMM	0.2	0.3	0.5	0.3	0.3	0.6
MET	1.1	4.5	5.6	0.9	8.5	9.3
FBM	0.6	1.5	2.1	0.5	1.3	1.8
MEQ	3.6	3.3	6.9	2.2	2.3	4.5
CEQ	0.1	1.2	1.3	0.0	0.8	0.8
ELQ	0.3	1.4	1.7	0.7	1.0	1.7
MTR	25.5	5.7	31.3	25.7	3.5	29.2
TRQ	0.0	0.1	0.1	0.0	0.1	0.1
OTM	0.1	0.2	0.3	0.1	0.3	0.4
EGW	1.6	1.3	2.9	1.2	1.3	2.5
CON	0.0	0.3	0.4	0.0	0.4	0.4
WRT	5.1	10.2	15.3	3.3	10.2	13.5
HTR	0.3	0.4	0.6	0.1	0.4	0.5
TRN	1.2	3.4	4.7	0.7	3.7	4.4
PTL	0.7	0.7	1.3	0.5	0.6	1.1
FIN	2.1	2.8	4.9	2.3	2.7	5.0
REA	0.7	1.0	1.7	0.4	1.0	1.4
RMQ	0.1	0.3	0.4	0.0	0.3	0.3
ITS	0.2	0.5	0.6	0.1	0.5	0.6
BZS	0.4	2.6	3.0	0.5	2.6	3.2
GOV	0.0	0.1	0.1	0.0	0.2	0.2
EDU	0.0	0.1	0.1	0.0	0.1	0.1
HTH	0.0	0.1	0.1	0.0	0.1	0.1
OTS	0.6	0.4	1.0	0.6	0.6	1.2
PVH	0.0	0.0	0.0	0.0	0.0	0.0
Total	48.5	51.5	100	43.5	56.5	100

Source: Calculated from the ICIO tables for 2000 and 2011 (OECD).

Note: For the sector classification, see the Appendix.

¹ This work is a major revision of “The Automotive Value Chain in Thailand (ERIA-DP-2016-33)”, and it was supported by JSPS KAKENHI Grant Number 17K03749.

² For instance, in recent years, Yazaki and Toyota Boshoku in Thailand relocated labor-intensive manufacturing facilities of a wiring harness and an automotive sheet cover to Cambodia and Laos, respectively.

³ In production fragmentation, production blocks are connected by service links, that is, bundles of activities consisting of transportation, insurance, telecommunication, quality control, and management coordination, to ensure that they interact in a suitable manner (Arndt and Kierzkowski, 2001).

⁴ According to Lall, Albaladejo, and Zhang (2004), the intensity of fragmentation differs because of four factors: the technical divisibility of production processes, the factor intensity of the process, the technological complexity of each process, and the value to weight ratio of the product. Considering the above factors, Lall (2003) concludes that fragmentation is strong in motor vehicles (a medium-tech industry), electronics (a high-tech industry), and clothing, footwear, sporting goods, and toys (low-tech industries).

⁵ In international input-output tables, parts and components are not separated from the motor vehicle sector. Thus, in this study, parts and components are defined as intermediate inputs produced and provided by the motor vehicle sector. Other categories of inputs used by the motor vehicle sector but produced by other sectors (e.g., electronics parts, rubber products, metal products, and plastics products) are not treated as automotive parts. By contrast, transactions of complete vehicles are captured in final demand sectors because they are used mainly for final consumption and capital formation.

⁶ In the Ghosh model, the accounting identity on the input side is expressed as $\mathbf{x}' = \mathbf{i}'\mathbf{Z} + \mathbf{v}'$. Then, the output coefficients matrix is obtained by $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$. Substituting this into the above equation yields $\mathbf{x}' = \mathbf{x}'\mathbf{B} + \mathbf{v}'$. Finally, \mathbf{x}' is given by $\mathbf{x}' = \mathbf{v}'(\mathbf{I} - \mathbf{B})^{-1} = \mathbf{v}'\mathbf{G}$, where \mathbf{G} is the Ghosh inverse matrix. Differentiating X_j^s (total output for sector j in country s) with respect to v_i^r (value added for sector i in country r) gives $\frac{\partial X_j^s}{\partial v_i^r} = g_{ij}^{rs}$. Then, the row vector of sector i in country r of the Ghosh inverse matrix, $\mathbf{g}_{(i)}^{(r)}$, indicates the output of all sectors in all countries induced by one unit of primary inputs for sector i in country r (for the technical details of the Ghosh model, see Chapter 12 in Miller and Blair (2009)).

⁷ As there are substantial leakages of value added (out of the home country) in the upstream production process, the actual dependency on foreign inputs is estimated only by calculating the percentage share of value added generated abroad (i.e., foreign content). Suppose, for example, the Thai automotive industry procures US\$ 8,000 of its parts and components from domestic suppliers and US\$ 2,000 from foreign suppliers. However, the domestic suppliers need to import US\$ 3,000 of materials from abroad. Then, the actual dependency on foreign inputs is 50 percent as opposed to 20 percent (if neither the foreign suppliers nor the foreign material producers import from Thailand).

⁸ Baba (2005) examines the trend of domestic procurement of the motor vehicle industry in the ASEAN4 countries (i.e., Thailand, Malaysia, Indonesia, and the Philippines). He finds that the share of domestic procurement increased only slightly (43.5 percent to 45.6 percent) during 1975–1990 but started to rise rapidly (45.6 percent to 50.8 percent) during 1990–1995. Tables 1 and 2 also show that the number of parts suppliers in Thailand increased sharply during 1986–1999. These facts suggest that the automotive parts industry in Southeast Asia started to develop significantly in the early 1990s.

⁹ The LCR policy significantly raised the cost of automotive parts. Simultaneously, Thailand imposed high tariffs as well as non-tariff barriers on completely built vehicles. For example, the introduction of the LCR system was accompanied by an upward adjustment in import tariffs on

completely built units of passenger vehicles, vans, and pick-up trucks to 80 percent, 60 percent, and 40 percent, respectively (Athukorala and Kohpaiboon, 2010). Such welfare costs should be taken into account to evaluate the LCR as a policy intervention.

¹⁰ Some successful local firms such as the Thai Summit Group received substantial benefits from the LCR policy. Starting as small enterprises during the LCR regime, these firms not only had their customers, but also received technical advice and support from foreign assemblers and parts suppliers. Today, with annual sales of US\$ 2 billion, the Thai Summit Group has more than 40 subsidiaries and produces a variety of automotive parts including car bodies; interior/exterior parts; wire harnesses; chasses; machine, forging, and die casting; and tooling.

¹¹ More specifically, engine manufacturers had to procure locally: cylinder blocks from 1994; connecting rods and camshafts from 1996; cylinder heads from 1997; and crank shafts from 1998 onward (Techakanont, 2011).

¹² The value of imported parts per locally assembled vehicle continued to decline until 2005. However, it started to rise again after 2005 (see Figure 5 in Warr and Kohpaiboon (2017)), consistent with the trend in Figure 2 in this paper. Warr and Kohpaiboon (2017) focus on imported automotive parts, while this study takes into account all the types of inputs used throughout the production process. Thus, the results of the analysis could be somewhat different.

¹³ The other factor affecting the localization of automotive parts is exposure to exchange rate risk, which can be reduced by increasing the share of locally procured parts and components (Kohpaiboon and Yamashita, 2001). In addition, the localization of R&D activities and development of new vehicle models (e.g., Toyota's IMV project) started in the 2000s. Geographical proximity facilitates face-to-face communication and product development coordination between suppliers and assemblers (Dyer, 1994).

¹⁴ The (total) share of foreign service content in Thai automotive exports increased slightly from 24.2 percent to 24.7 percent during 2000–2011.

¹⁵ Although mining products cannot be used directly by the motor vehicle industry, it does use inputs from the basic metals sector, which, in turn, uses inputs from the mining sector. Thus, motor vehicle production indirectly induces value added in the mining sector.

¹⁶ The total number of transactions recorded in the ICIO table is large; 509,796 ($= (34 \times 21)^2$) intermediate transactions plus 714 ($= 34 \times 21$) value added transactions. Thus, the shares (in terms of the number) of transactions that appear in Figures 3a–4b are small, but their shares in transaction values are not. For example, the shares of value added (primary inputs) and final output captured in Figures 3a and 4a are 59.1 percent and 75.6 percent, respectively. Thus, these figures are expected to capture the lion's share of transaction values in the value chain.

¹⁷ As discussed above, the production share of commercial vehicles (in particular, 1-ton pickup trucks) is high in Thailand; the share of 1-ton pickup trucks in 2014 was 53 percent. This automatically increases the share of motor vehicles used for capital formation.