

Global Backward and Forward Multiplier Analysis: The Case Study of Japanese Automotive Industry

Sutee ANANTSUKSOMSRI^{1,2}, Nattapong PATTANAPONG³, and Nij TONTISIRIN⁴

¹ Waseda University, Waseda Institute for Advanced Study, 1-6-1 Nishi Waseda, Shinjuku-ku, Tokyo 169-8050, Japan

² Chulalongkorn University, Faculty of Architecture, Department of Urban and Regional Planning, 254 Phayathai Road, Pathumwan, Bangkok 10330, Thailand

³ Thammasat University, Faculty of Economics, Tha Prachan Campus, 2 Prachan Road, Phranakorn, Bangkok 10200, Thailand

⁴ Thammasat University, Faculty of Architecture and Planning, Rangsit Campus, Pathumthani 12121, Thailand

Abstract

Thailand is one of the major investment destinations of Japanese auto-motive industry. In addition to the major automobile companies, Japanese investors have also invested in small- and medium-enterprises in automobile parts and components in Thailand. Since the 80's, the automotive industry has been a driving force of the Thai economy. Currently, Thailand is one of the world largest automobile producers. In this study, we analyze the Global Input-Output Table. Backward and forward multiplier analysis is used to conduct inter-industry linkage analysis of Japanese automotive industry. Unlike a conventional trade statistical analysis, this global input-output table allows for the analysis of interconnection between economic sectors around the world. From our multiplier analysis, Japanese automotive industry has high backward linkages domestically. Internationally, its forward multiplier is among the top five after metal, chemicals & rubber, electrical & optical equipment, and wholesale & retail. In addition, structural path analysis is performed to illustrate the paths of global value chain of Japanese automotive industry. The analysis reveals the interconnection of automotive and other industries in Japan, Thailand, and the rest of the world.

Keywords: Automotive Industry, Input-Output, Structural Path Analysis

Introduction

The automotive industry consists of a wide range of activities including design, research and development, manufacturing, and marketing. These economic activities have taken place worldwide. In particular, Japanese automotive industry has taken the advantages of global value chain. As we can observe in a car assembling process, a manufacturer uses intermediate inputs from around the world. After the 1985 Plaza Accord, Japanese automotive industry has moved their production bases to many developing countries. These Japanese direct investments in other countries not only benefit the economies of the countries where factories are located but also the economy of Japan. However, increasing global interdependence of automotive producers may cause disruption in production if a producer of intermediate inputs in one country halts its production due to some difficulties from an economic crisis or disaster. In 2011, for example, the global supply chain of automotive industry faced difficulty from the impacts of Tsunami in Japan and flood in Thailand, emphasizing the vulnerability of the global value chain.

Thailand is one of the major investment destinations of Japanese automotive industry. It is the largest automobile producer in Southeast Asia and one of the largest producers in the World. Japan is the largest investor in Thailand in terms of amount of investment and number of projects. In addition to the major automobile companies such as Toyota, Honda, Nissan, Mazda, and Isuzu, Japanese investors has also invested in small- and medium-enterprises in automobile parts and components in Thailand. The automotive industry is a driving force of the Thai economy. It ranks the fifth largest export industry and accounts for ten percent of the GDP of the country, employs more than 500,000 direct skilled-labor jobs, and creates spillover effects to other industries in the economy.

In this study, we analyze the Global Input-Output Table, which is publicly available on the World Input-Output Database (WIOD). In addition, we introduce the methodology of extending the WIOD table to cover additional data of Thailand based on sectoral distribution data from Global Trade Analysis Project (GTAP). Backward and forward multiplier analysis is used to conduct inter-industry linkage analysis of Japanese automotive industry. Unlike a conventional trade statistical analysis, this global input-output table allows for the analysis of interconnection between economic sectors around the world. From our multiplier analysis, Japanese automotive industry has higher backward linkages domestically. Internationally, its forward multiplier is among the top five after metal, chemicals & rubber, electrical & optical equipment, and wholesale & retail. In addition, structural path analysis is performed to illustrate the influence of global value chain of Japanese automotive industry. The analysis reveals the strong interconnection of automotive industry and other industries in Japan, Thailand, and the rest of the world.

Global Value Chain and World Input-Output Databases

This increasing interdependence of different economic sectors across the globe has developed a need for more comprehensive databases that can be used to analyze such phenomenon. Global Trade Analysis Project (GTAP) was founded in the early 90's as a network for researchers interested in global analysis issues. GTAP serves as a framework for multilateral trade analysis and provides data, models, and resources. Nonetheless, GTAP database is still needed to be adjusted to reflect more accurate trade balance. To analyze value-added from international supply chain, Ahmad et al. (2011), Daudin et al. (2009), Johnson and Noguera (2012), and Koopman et al. (2008 and 2011) used the GTAP database and found the values of trade balance have to be adjusted

to reflect the volume of international shipment of intermediate goods. In Koopman et al. (2011), when adjusted, the US's trade deficit to China may decrease about 30-40%.

The notion of accounting for international supply chain has established a collaboration to create a global input-output database. Based on the data structure concept and applications of Leontief and Strout (1963) and Sanyal and Jones (1982), the World Input-Output Database (WIOD) was constructed by Dietzenbacher et al. (2013). The WIOD is a result of the compilation of 1995-2011 annual statistics of international trade and production structure of 35 sectors and 40 economies. The development of WIOD tables leads to the widespread application, especially for a deeper and broader insight of global production network. These WIOD tables are also main data sources for Timmer et al. (2013) and Ottaviano (2014) to study impacts of the global production network on European economy. However, there is a limitation on a specific country's application due to the limited number of economies covered in the original data set. Therefore, this study introduces the methodology of extending the WIOD table to cover additional data of a specific economy. The method is described in the following section.

Methodology

World Input-Output Database Tables

World Input-Output Database (WIOD) serves as an important data system for analyzing the global value chain of Japanese Automotive industry in this study. The WIOD contains sectoral transactions of 35 sectors in 40 major economies from 1995 to 2011. Since Thailand is not a country on the list of WIOD table, it is necessary to modify WIOD table so that it explicitly shows the trade and production statistics of Thailand. There are two major steps involved in this modification procedure. First, the dimension of WIOD table must be adjusted so that it is compatible with those of GTAP's global trade data because GTAP data is the main source of Thailand trade and production data. The second step involves consolidating two sources of data from WIOD and GTAP to formulate a modified WIOD table. In this study, 2007 data are used because it is the latest matching year for both WIOD table and GTAP's data (Puttanapong, 2015). The consolidation of the WIOD table and GTAP's data yields the global input-output table explicitly with Thailand economy.

Structural Path Analysis

Structural Path Analysis (SPA) can be employed as an extension of the input-output analysis to identify and measuring flows in economy (Defourny and Thorbecke, 1984). SPA decomposes the input-output multipliers and identifies a network of paths that are transmitted in the economic system. We calculated the multiplier effects of World Input-Output Tables using the MATLAB code, originally developed by Cornell University Center for Advanced Computing (CAC).

Results

Japan Backward and Forward Multipliers

Backward and forward multipliers of Japanese sectors are calculated to show the linkages to both domestic and international industries. Figure 1 shows domestic backward and forward linkages of production sectors in Japan. Transport Equipment sector is used as a proxy to the automotive industry. Among the 26 sectors, the automotive industry has the highest domestic backward multiplier, suggesting a strong interconnection of the automotive industry and its local suppliers. As expected, Wholesale, Retail, Hotel, & Restaurant sector has the highest forward multiplier. Although the forward multiplier of the automotive industry is not the highest domestically, it is among the top ten industries that have strong domestic linkages. Internationally, Japan automotive industry is among the highest forward multipliers industries. As shown in Figure 2, the forward multiplier of Japan automotive industry is the fifth highest, following Metal, Chemical & Rubber, Electrical & Optical Equipment, and Wholesale, Retail, Hotel, & Restaurant sectors, respectively. The high forward multiplier of automotive industry suggests the strong interconnection of Japan automotive industry to its customers around the world.

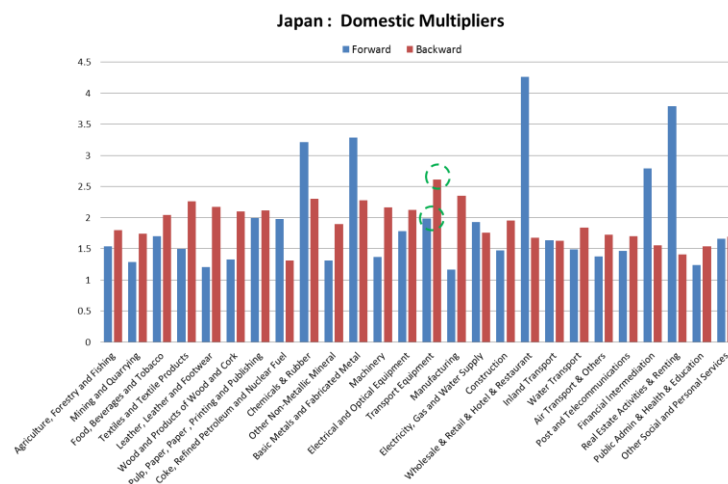


Figure 1: Japan Domestic backward and forward multipliers

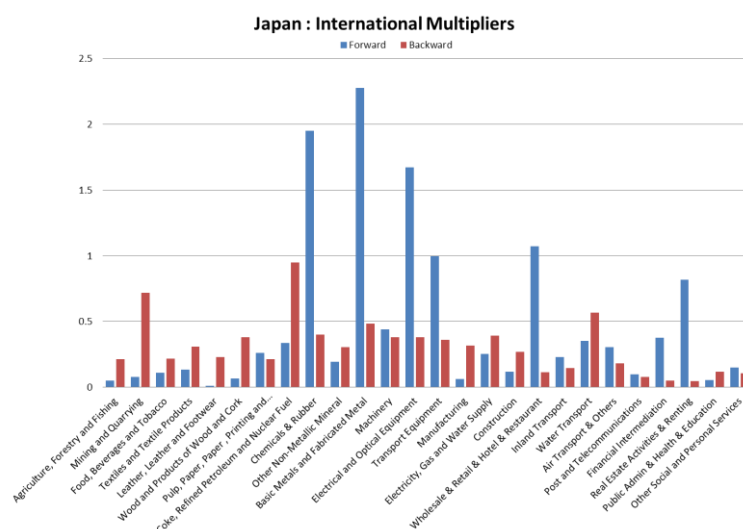


Figure 2: Japan International backward and forward multipliers

Thailand Backward and Forward Multipliers

Thailand domestic backward and forward multipliers are shown in Figure 3. The sectors in Thailand with the highest domestic backward multiplier are: (1) Inland Transport, (2) Food, Beverage, & Tobacco, (3) Air Transport, (4) Textiles, and (5) Water Transport, respectively. Unlike Japan, the automotive industry in Thailand does not have a strong backward linkage locally. On the other hand, the sectors in Thailand with the highest domestic forward multiplier illustrate the manufacturing-based nature of Thailand economy. These sectors with the highest domestic forward multiplier are (1) Coke, Refined Petroleum & Nuclear Fuel, (2) Wholesale, Retail, Hotel, & Restaurant, (3) Mining, (4) Electricity, Gas, & Water Supply, and (5) Chemical & Rubber, most of which are intermediate inputs for production. Overall, automotive industry in Thailand has a moderate forward and backward linkage locally.

Thailand international multipliers, however, are different from its domestic multipliers. Figure 4 shows international backward and forward multipliers of Thailand sectors. Internationally, backward multipliers of sectors in Thailand are significantly higher than forward multipliers. These high backward multipliers suggest that Thailand industries are strongly linked to the global supply chain through their international suppliers. The sectors with the highest backward multipliers are: (1) Machinery, (2) Automotive industry (Transport Equipment), (3) Construction, (4) Metal, and (5) Electrical & Optical Equipment, respectively. The multipliers also show that Thailand industries rely on their international suppliers much more than Japan industries.

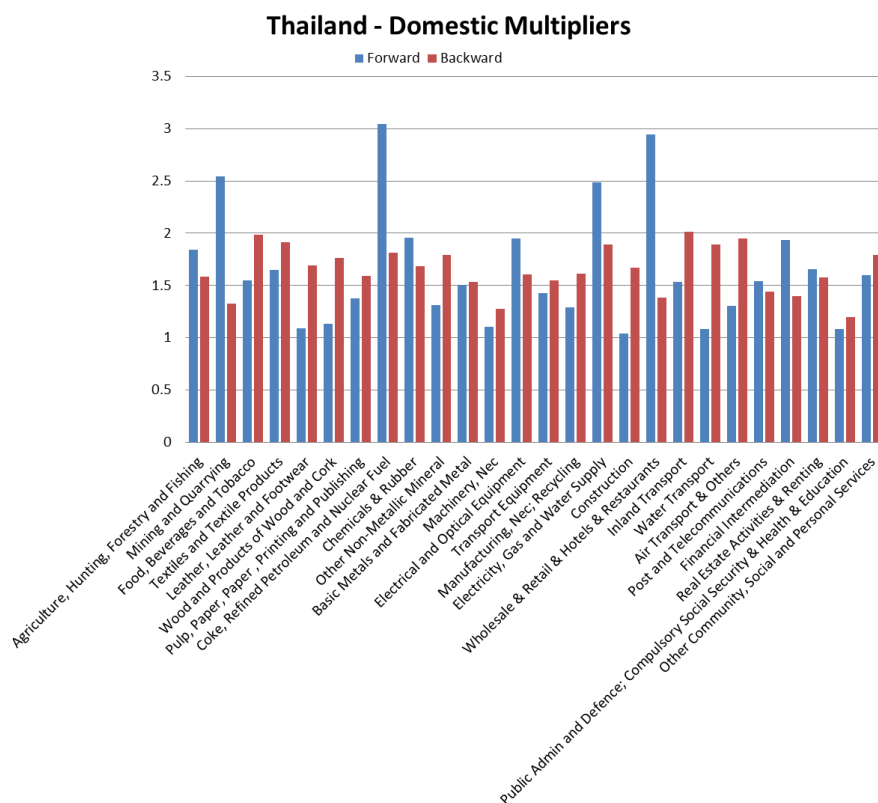


Figure 3: Thailand domestic backward and forward multipliers.

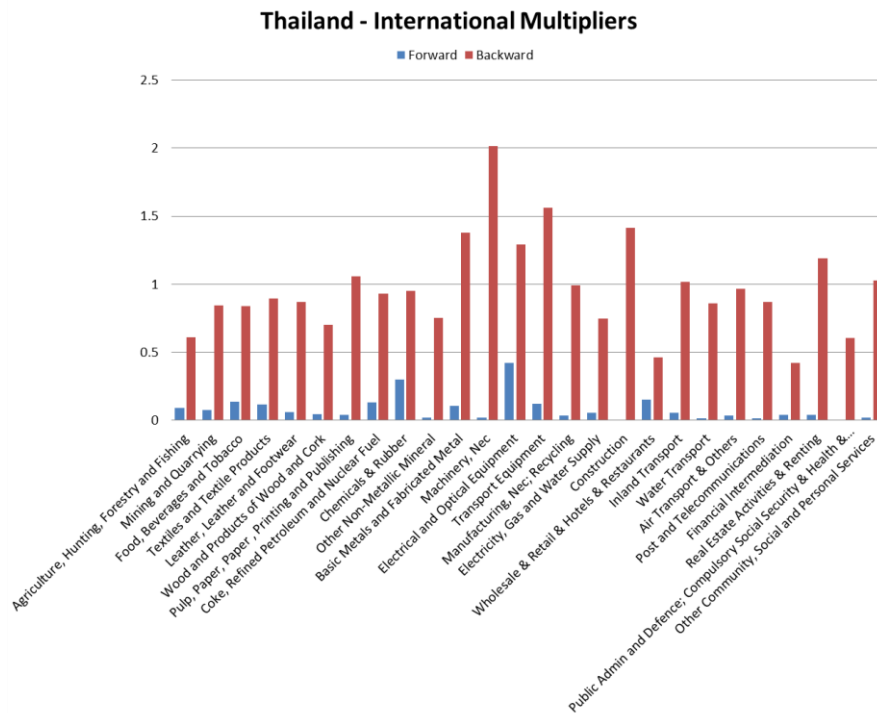


Figure 4: Thailand international backward and forward multipliers.

Structural Path Analysis

The Top 100 Highest Influence Values

To analyze the global influence of Japan industries, multipliers of all sectors from eight economies are decomposed and ranked. Among the 100 highest influence paths, 77 paths are originated in Japan, while the remainder is from other seven economies. The sum of total influence from Japan is 0.78, which accounted for 90 percent of the sum of total influences of these highest 100 paths. The results suggest the dominance of Japan industries and its interconnectedness to the global economies.

The Top 200 Highest Influence Values

Out of the top 200, 145 paths have originated in Japan, while the other 55 are originated elsewhere. Japan sectors are among the top that is the source of most of the highest influences to the global economy. In comparison to 145 paths from Japan, 11 paths are from China, 9 from European economies, and 11 from the United States. Out of these 145 paths, Basic Metals and Fabricated Metal is the sector with the highest value of influences with 33 paths, followed by 24 paths from Chemical & Rubber sector, 18 paths from Wholesale, Retail, Hotel, & Restaurant, and 18 paths from Electrical and Optical Equipment. Automotive industry is ranked the ninth in Japan and has originated 6 paths with the influence value of 0.021. As for Thailand, there are two sectors that have high influence from Thailand: transport equipment and Electrical & Optical Equipment sectors.

Conclusions

The change of production process has made economies throughout the world increasingly interconnected. A country specializes in a particular stage of the production of goods and becomes a part of international supply chain. International trade is no longer for raw materials or final goods but for intermediate inputs for a production of goods. As a result, economies throughout the world become highly interlinked through this network of international supply chain.

Japanese automotive industry is among the industries that take advantage of this global value chain since the automotive industry involves many production processes, from design, manufacturing, to marketing. A car, for example, may be designed in Japan, while the car assembling process may take place in a plant in Thailand using the intermediate inputs from around the world. This study examines the global backward and forward multiplier of industries in Japan and Thailand, focusing on the automotive industry, as well as global influences of production sectors from 8 economies. It employs input-output multiplier analysis and structural path analysis as an analytical framework. The analysis utilizes the World Input-Output Database (WIOD) table as a data system with some modifications to incorporate Thailand data in the table. Inland transport sector is used as a proxy for automotive industry.

The results of input-output multiplier analysis show that domestically Japan automotive industry has a very strong backward linkage to other local industries. Internationally, Japan automotive industry is among the top sectors with high forward influence. Thailand automotive industry does not have as strong domestic linkage as Japan. However, Thailand automotive industry is the second highest backward linkage to international economies. The results of the structural path analysis reveal that Japan is the leader in generating economic impacts both locally and globally. Japan industries contribute to 77 out of 100 highest influence paths and 145 out of 200 highest influence paths in the world. Japan automotive industry originates 1 dominant impact in the top 100 and 6 paths in the top 200.

The extensions of this analysis include disaggregating automotive industry from inland transport sector and building a global CGE model to examine the interconnection of the automotive industry to other economies in the world.