Economic Linkage in the Thai Rubber Industry and Cluster Identification: Input-Output Approach

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Abstract
This research aims to analyse the linkage effect of the Thai rubber industry to other sectors in the Thai economy, identify the Thai rubber cluster, and create a rubber cluster map. The research utilises input-output analysis to ascertain the economic linkage of the Thai rubber industry, employing the cluster mapping concept to identify relative industries and institutions in the cluster. Input-output data from the Office of the National Economic and Social Development Council input-output table 2010 (matrix 180x180) is used to analyse the linkage effect of related industry sectors. The four core sectors are rubber, rubber sheets and block rubber, tyres and tubes, and other rubber products. The results show that overall, the rubber sectors have a 42.27 per cent direct backward linkage and a 36.60 per cent direct forward linkage. Overall, the four rubber sectors have a higher total backward index (0.99) than total forward index (0.93). The rubber sectors have a backward linkage to 27 sectors and forward linkage to 21 sectors. There are four groups of backward linkage: raw materials, machinery and equipment, business supporter, and infrastructure. In the same way, there are five groups of forward linkage: automotive, houseware, services, transport, and others. In conclusion, the Thai rubber industry buys input factors from other industries rather than distributing output to other industries. Hence, the government should be utilising a cluster map to promote the Thai rubber cluster for creating knowledge, innovation, and new business in the country.
Keywords: Backward linkage, Forward linkage, Input-output analysis, Rubber industry, Industrial cluster

Introduction
The concept of industrial clusters has been developed from Marshallian externalities based on local knowledge spillovers, labour market pooling, and specialised suppliers (Boschma, 2015: 859-861). A cluster is a critical mass of companies in a particular field and location, whether a country, state, region, or even city (Porter, 1998a: 78-79). This relates to the definition of industry clusters, defined by the United Nations Industrial Development Organization (UNIDO) as "…Geographical concentrations of interconnected enterprises and associated institutions that face common challenges and opportunities…" (Porter, 1998a: 78; United Nations Industrial Development Organization, 2013a: 9). According to this definition,

industrial clusters have to include three criteria. There are geographic concentrations, linkage or similarity of companies/institutions in the area, and government policy to promote and support cluster. Moreover, agglomeration of related businesses in the form of clusters results in knowledge creation, innovation, the accumulation of skills, and the development of pools of employees with specialised expertise (Porter, 2007: 2). Furthermore, the industrial cluster affects competition by increasing the productivity of companies based in the area, driving the direction and pace of innovation, which underpins future productivity growth, and stimulating the formation of new businesses to expand and strengthen the clusters itself (Porter, 1998b: 80).

Several studies have reported the impact of industrial clusters on the improvement of productivity and competitiveness (Hsu, Lai, and Lin, 2013: 130017-5; Arimoto, Nakajima and Okazaki, 2014: 27-30; Vlasceanu, 2014: 52-56). Since industrial clusters can access strategic resources, knowledge, technologies, information, infrastructures and the relationships of economic entities within the clusters, they also create positive effects (Hoffmann et al., 2011: 87-88; Niu et al., 2012: 133-135; Hsu, Lai, and Lin, 2013: 130017-2).

In Thailand, the government utilises the cluster concept to improve industrial development. The cluster concept became popular in Thailand after the 1997 economic crisis (Tom Yam Kung crisis) and was formally initiated during the Ninth National Economic and Social Development Plan (1999-2004) (Santipolvut and Mali, 2015: 1259). The government utilises cluster policies to improve the competitiveness of many industries. The Super-Cluster Policy 2016 (The Office of the Board of Investment, 2016), and industrial cluster policy are fundamental to Thailand’s industrial development strategies 2012-2031 (Office of the Permanent Secretary, Ministry of Industry, 2011).

The rubber industry is one of the important sectors where the Thai government utilises its cluster policy to promote industry development, since, it is a mechanism for generating income and employment in both the agriculture and industry sectors. This is evidenced by production in 2014 amounting to 4,324 tons (Pumkaew et al., 2018: 104). Moreover, rubber products are the main exports of Thailand. Thai rubber production shows a continuous growth trend, with most of the outputs produced for export (Figure 1).

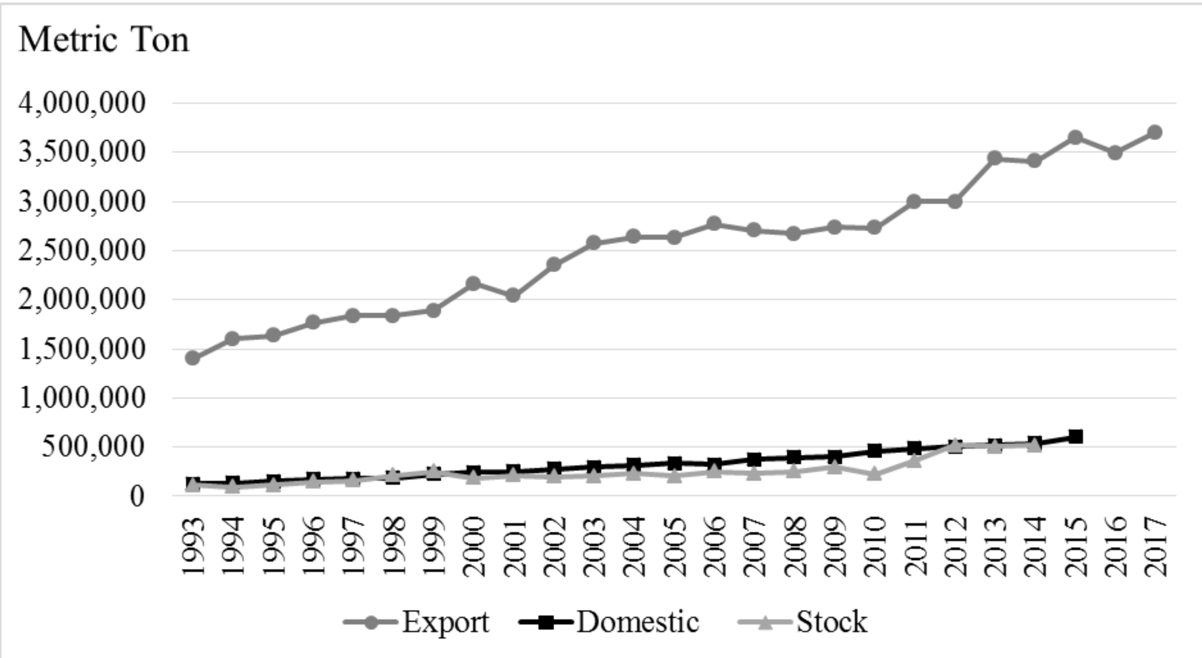

Figure 1 Rubber production and usage in Thailand in 1993-2017
Source: Rubber Authority of Thailand (2018)

However, rubber prices have fluctuated and the trend has declined over the past ten years due to the oversupply of raw rubber, economic slowdown, decline in oil prices, increased competition, fewer processed products, and other economic factors. Moreover, the Thai rubber industry lacks the necessary technology and innovation to produce new rubber products (Rubber Authority of Thailand, 2018). These are the main problems affecting the rubber industry, especially rubber plantation losses due to high costs. Thus, the Thai rubber industry has three critical problems: 1) most of the output is used for export as raw rubber with low value added; 2) output prices are declining; and 3) there are few intermediate and final rubber products in the value chain.

Consequently, industrial cluster policies could be effective in promoting the competitiveness of the Thai rubber industry. However, Thailand does not have an efficient rubber cluster to encourage competitiveness. Thus, this study explores the characteristics and economic linkage between the rubber industry and other economic sectors in Thailand to identify the structure of a potential rubber cluster in the country.

Research Objectives

The objectives of this research are:

1) To analyse the economic linkage between the Thai rubber industry and other sectors in the Thai economy.

2) To identify a Thai rubber cluster and create a rubber cluster map.

Literature Review

1) Concepts and theories on industrial clusters: The industrial cluster concept has been used as a policy to promote industrial development in various counties since it affects industrial competition in three ways. First, clusters increase the productivity of companies based in the area. Second, they drive the direction and progress of innovation to support future productivity growth. Third, they stimulate the establishment of new businesses to expand and strengthens the clusters (Porter, 1998a: 80). The competition in advanced economies is driven by knowledge, innovation, and labour skills. Industrial cluster is a concept which creates knowledge, innovation, the accumulation of labour skills, and develops pools of specialised employees among firms in the clusters (Porter, 2007: 2). Furthermore, cluster networks are key drivers of job growth, wage growth, new business formation, and innovation (Porter, 2007: 3).

2) Cluster identification: In recent years, many published research papers contain methods for identifying industrial clusters. At present, widely used cluster identification methods consist of location quotient, input-output, principal component analysis, multiple clustering, geographical mapping, and Gini coefficient (Haitao and Hongwei, 2010: 131). Generally, cluster identification techniques can be separated into two data types: (1) employment data (e.g. location quotient (LQ), locational Gini coefficient and an agglomeration index); and (2) input-output data (e.g. identifying the maximum values of forward/backward linkage, simplifying I-O tables using a three-fold cut-off scheme, identification of clusters using graph theory, and comparing sales and procurement profiles) (Lublinski, 2002: 21-23).

3) Cluster identification techniques using input-output data: Input-output analysis is the name given to an analytical framework developed by Professor Wassily Leontief in the late 1930s. The term inter-industry analysis is also used since the fundamental purpose of the input-output framework is to analyse the interdependence of industries in an economy. In its most basic form, an input-output model consists of a system of linear equations, each one describing the distribution of an industry’s product throughout the economy. Most extensions to the basic input-output framework are introduced to incorporate additional details of economic activity, such as overtime or space, to accommodate the limitation of available data or connect input-output models to other kinds of economic analysis tools (Miller and Blair, 2009: 1). Input-output analysis uses basic information involving the flow of products from each industry, considered as a producer, to their own sectors and others considered as consumers. The input-output table contains data on inter-industry transactions in the economic sector with the rows describing the distribution of a producer's output throughout the economy. The columns describe the composition of inputs required by a particular industry to produce its output (Miller and Blair, 2009: 2-3).

The use of input-output data to identify groups of industries inter-linked by the flow of goods and services involves various approaches. The simplest way to identify a cluster is to group the sectors linked by maximal input-output flows, by "shaking out" all weak values from the input-output table (Lublinski, 2002: 39). However, the advantage of this method is its ability to identify an industrial cluster from the real structure of economic linkage.

4) Cluster mapping concept: According to the International Trade Department of The World Bank (2009: 14-17), the definition and implementation of cluster mapping involve the contextualisation of a specific cluster of economic activities within the overall economy. An overall economic outline is created to indicate activities related to the core cluster industry such as sales, suppliers, service providers, educational and research activities, and regulatory bodies.

The cluster map consists of two dimensions: 1) clustering, depending on the related industrial classification code; and 2) specifying the geographical locations at the centre of related sectors. The steps for identifying cluster components are as follows:

4.1) Analysing the vertical chain of firms and institutions.

4.2) Horizontal analysis to identify industries that pass through common channels or produce complementary products and services, identified on the basis of similar specialised inputs or technologies or supply linkage.

4.3) To isolate the institutions providing specialist skills, technology, information, capital, or infrastructure and any collective bodies covering participants.

4.4) To seek out government or other regulatory bodies significantly influencing participants in a cluster (Danuvasin, 2017: 2-3).

Empirical Review

The related research focusing on the method of cluster identification and linkage between economic entities in selected clusters has been studied by numerous scholars. Feser and Bergman (2000) investigated the available information on national interindustry linkage to identify potential clusters in subnational regions. They computed the direct and indirect linkages from interindustry trade information on each sector and treated these as variables in principal component analysis. Sampling was derived from a set of 23 US manufacturing clusters. The results show that template clusters can be useful as a primary source in an extensive inspection of local cluster patterns and can also help to find gaps and specialisations in product chains.

Subsequently, Lublinski (2002) explored the concept of cluster identification and applied it to an aeronautics cluster in Northern Germany. This research reviewed lots of literature related to industrial cluster identification methods. These methods were separated into two types of data sources (employment and input-output). Moreover, Lublinski (2002) considered two cluster dimensions: the geographical (firms in the cluster are geographically concentrated and proximate) and functional (firms in the cluster are inter-linked by various types of linkage flow), generating agglomeration advantages. For the geographical dimension, he employed the local quotient technique to identify a cluster search area. The surveys were conducted using 111 firms with an aeronautic affinity in Germany and a control group of 68 firms. The results show that firms in clusters have a significantly higher innovation performance, productivity, and/or profitability compared with spatially dispersed firms.

Duque and Rey (2008) proposed a new methodology to identify industry clusters based on graph theory. The input-output linkage between industries is simplified using network analysis. This method can be used to compare regional industrial cluster across space and time. Subsequently, Duque, Rey, and Gomez (2009) applied this method to identify industry clusters in Colombia. Since this methodology allows each industry to be classified in a given cluster, it also promotes the understanding of how industries are related to each other within their clusters. The advantage of this methodology is its ability to indicate the key industry within the cluster whose resources can generate the biggest impact on the whole economy. Moreover, Catini et al. (2015) proposed a methodology for identifying clusters with the application of a graph approach based on K-shell decomposition to analyse world biomedical research clusters found in PubMed scientific publications. According to the results, research institutions can be identified and activities in geographical clusters located. Additionally, it can be concluded that the performance of research institutions is influenced by different geographical scales.

From the perspective of mixed methods, Brachert, Titze, and Kubis (2011) identified industrial clusters using a multidimensional approach. Their research utilised a combination of concentrated measures and input-output methods to identify the horizontal and vertical dimensions of industrial clusters in Germany, suggesting a three-step approach: 1) identify an industrial cluster with help of the Sternberg and Litzenberger (2004) Cluster Index; 2) apply QIOA and allow the sectoral interdependence of local industrial cluster structures to be controlled and identify their horizontal and vertical dimensions; 3) control the spatial interdependence of identified industrial cluster structures and allow the local and regional industrial cluster structures to be distinguished, contributing to an adequate framework of industrial cluster identification. Within the multidimensional approach, Titze, Brachert, and Kubis (2014) studied the empirical literature on the identification of industrial cluster methodology to identify the production and knowledge generation activities of industrial clusters in the Federal State of Saxony in Germany. A combination of the following methods has been employed: the measurement of spatial concentration, qualitative input-output analysis, and a knowledge interaction matrix. The results show that a high-tech industrial cluster in a semiconductor industry drives a small overlap in cluster production and knowledge generation activities in the region. However, the identification of innovative actors was limited by focusing solely on production activities for industrial cluster analysis. Stejskal and Hajek (2012) explored and suggested a new method for industrial cluster identification. This research confirmed that Porter’s diamond model of the cluster competitiveness environment formed the substance of the novel method, resulting in a technique to calculate the competitive advantage score through hierarchical principal component analysis. According to the literature review, this research applies the concepts and methods to analyse the Thai rubber industry.

Research Methodology

Data used in this research consists of: 1) secondary data and in-depth interviews with representatives of rubber firms and related institutions in order to describe the characteristics of the rubber industry and rubber clusters in Thailand; and 2) input-output (I-O) data from four rubber sectors according to the NESDB Input-Output Table 2010 (matrix 180x180) to analyse the linkage effect of related industry sectors. The rubber industry relates to four core sectors as follows:

2.1) I-O code 016 (rubber) representing latex from the rubber tree.

2.2) I-O code 095 (rubber sheets and block rubber) representing sheets, block rubber, crepe rubber, and other processed rubber.
2.3) I-O code 096 (tyres and tubes) representing all types of tyres and tubes such as those for cars, trucks, buses, tractors, motorcycles, and bicycles.
2.4) I-O code 097 (other rubber products) representing the manufacture of rubber products not classified elsewhere such as raincoats, gloves, bags, mats, toys, bands, hoses, tubes, bottles, and sponges (Office of the National Economic and Social Development Council, 2018).

Data analysis

This research uses both qualitative and quantitative methods, divided into two parts as follows:
1) The qualitative method shows the character and status of Thai rubber clusters. Descriptive and content analysis is applied according to cluster initiative, cluster mapping, and other cluster concepts.
2) The input-output analysis technique is used to identify the linkage effect of the rubber industry on other sectors in Thai economy. Relevant industries and institutions are then identified in the rubber cluster using the cluster mapping concept.

Input-output analysis

To identify the economic linkage of a Thai rubber cluster, the intermediate transactions of four core rubber sectors, both backward and forward, are considered. An input-output model is applied to calculate the results of this research, consisting of the following principles (Tongsom, 2013: 86):
1) It is static.
2) It has a technical relationship rather than general equilibrium.
3) It is inter-industry dependent.
4) Any set of "correct" output levels for the n industries must be consistent with all the input requirements in the economy.

Assumptions

(1) Each industry produces only one homogeneous commodity.
(2) Each industry uses a fixed input ratio (or factor combination) for the purpose of its output.
(3) Production in each industry is subject to constant returns to scale.

Structure of inter-industrial transactions

The matrix X represents the n x n input-output (I-O) matrix of an intermediate transaction in the economy.

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} & x_{1n+1} \\ x_{21} & x_{22} & \cdots & x_{2n} & x_{2n+1} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} & x_{nn+1} \end{bmatrix}$$

The row shows the output distribution of industry i to industry j

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

Where
X_{ij} denotes the output transaction of industry i for produce j
X_i denotes the output of the rubber industry i (rubber, rubber sheets and block rubber, tyres and tubes, and other rubber products)
D_i denotes the final demand for the output of industry i
n denotes the number of all industrial sectors in the Thai economy
The column shows the input structure of each industry

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

Where
X_j denotes the output of industry j

V_j denotes the fundamental value-added l factors of industry j
Assume, industry i produces sufficient output to meet the input requirements of n industries as well as the final demand of the open sector.

Economic linkage

The linkage effect of industrial sectors in the economy can be measured using the forward and backward linkage index calculation. According to assumption (2),

$$X_{ij} = a_{ij} \,.\, X_j$$

or $a_{ij} = X_{ij}/ X_j$ (3)

Where

a_{ij} denotes the input or technical coefficients (the proportion of input i used in j production)

$$A = \begin{vmatrix} \frac{X_{11}}{X_1} & \frac{X_{12}}{X_2} & \cdots & \frac{X_{1n}}{X_n} \\ \frac{X_{21}}{X_1} & \frac{X_{22}}{X_2} & \cdots & \frac{X_{2n}}{X_n} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{X_{n1}}{X_1} & \frac{X_{n2}}{X_2} & \cdots & \frac{X_{nn}}{X_n} \end{vmatrix} = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & a_{ij} & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \quad (4)$$

Where

A denotes the coefficient matrix of intermediate input

Direct linkage

Direct backward/forward linkage is calculated by equations (5) and (6):

$$DB = \frac{\sum_i^n X_{ij}}{X_j} \quad (5)$$

Where

DB denotes the direct backward linkage

$\sum_i^n X_{ij}$ denotes the total intermediate input used in industry j

X_j denotes the total input value of industry j

$$DF = \frac{\sum_j^n X_{ij}}{X_i} \quad (6)$$

Where

DF denotes the direct forward linkage

$\sum_j^n X_{ij}$ denotes the total intermediate demand for the output of industry i

X_i denotes the value of total demand of industry i

If the percentage of DB and DF is high, it means that the rubber industry has a high linkage effect with other industries in the economy. However, the direct backward and forward linkage analysis calculated from matrix A was unable to measure changes in all outputs. Changes in output are caused by increasing/decreasing sales or service volume in some industries, affecting others both directly and indirectly. Hence, the total linkage measurement employs data in matrix A to calculate the Leontief inverse matrix $[I-A]^{-1}$ as follows:

$$[I-A] = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & 1 & \vdots \\ 0 & 0 & \cdots & 1 \end{bmatrix} - \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & a_{ij} & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (7)$$

Then, create inverse matrix ($[I-A]^{-1}$)

$$[I\text{-}A]^{-1} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{bmatrix} \quad (8)$$

Total linkage index

Calculation of the total backward and forward linkage index utilises the Leontief inverse matrix $[I\text{-}A]^{-1}$ as shown in equations (9) and (10).

$$TB = \frac{\sum_i^n b_{ij}}{\frac{1}{n}\sum_j^n \sum_i^n b_{ij}}; j=1,2,\ldots,n \quad (9)$$

Where

TB denotes the total backward linkage index

$\sum_i^n b_{ij}$ denotes the vertical sum of matrix $[I\text{-}A]^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ denotes the horizontal sum of matrix $[I\text{-}A]^{-1}$

n denotes the number of all industrial sectors in matrix $[I\text{-}A]^{-1}$

$$TF = \frac{\sum_j^n b_{ij}}{\frac{1}{n}\sum_i^n \sum_j^n b_{ij}}; j=1,2,\ldots,n \quad (10)$$

Where

TF denotes the total forward linkage index

$\sum_i^n b_{ij}$ denotes the horizontal sum of matrix $[I\text{-}A]^{-1}$

$\sum_j^n \sum_i^n b_{ij}$ denotes the vertical sum of matrix $[I\text{-}A]^{-1}$

If the results show a TB value of more than 1, this implies that the industry tends to have a backward linkage to other sectors (the value of raw material purchased from other sectors is higher than the average in the economy). Conversely, a TB value of less than 1 implies that the industry does not tend to have a backward linkage to other sectors (the value of raw material purchased from other sectors is lower than the average in the economy).

If the results show a TF value of more than 1, this implies that the industry tends to have a forward linkage to other sectors (the industry output distributed to other sectors is more than the average in the economy). Conversely, a TF value of less than 1 implies that the industry does not tend to have a forward linkage to other sectors (the industry output distributed to other sectors is less than the average in the economy).

Results

The results of this paper can be separated into three parts:

1) General characteristics of Thai rubber clusters

Qualitative analysis was used to provide information about the operational status and policies for developing rubber clusters in Thailand. A content analysis of secondary data and interviews with representatives of rubber firms, government agencies and related institutes indicated that there are many departments in the Thai government involved in the industrial cluster policies of the rubber industry. Each department has a different approach to promoting rubber clustering in each region. The cluster policy for promoting the rubber industry by the Department of Industrial Promotion, Ministry of Industry focuses on four aspects: 1) standard (product/process), 2) productivity, 3) innovation (product/process), and 4) network. There are three criteria for promoting rubber clusters in the eastern region: 1) geographical concentrations of rubber companies, 2) supporting businesses (logistics, port, finished product company, etc.), and 3) supporting organisations (five branches of the Rubber Authority of Thailand in the eastern region, University, BOI, etc.) (Director of industrial promotion, central region 9 interviewed on 3 April 2017). Furthermore, the Department of

Business Development's cluster policy is to enhance the competitiveness of SMEs by promoting southern rubber processing clusters, with the following mission: 1) to develop a management system and human resources development system for rubber clusters, 2) to develop a quality system with innovations to enhance the standard of rubber, and 3) to achieve the sustainable development of rubber clusters with good governance. However, Thai rubber clusters have many problems including 1) a lack of clarity in defining the agency responsible for promoting the rubber cluster, 2) the rubber cluster operation is not continuous, 3) a lack of knowledge and understanding about clustered operations, 4) entrepreneurs in the industry do not cooperate as much as they should.

2) Economic linkage in the Thai rubber industry

The results of economic linkage analysis (Objective 1) from input-output data are used to select the related sectors in a rubber cluster. Based on the results shown in Table 1, the rubber industry has more forward linkage with various other industries than backward linkage. The rubber sector (016) has more direct forward linkage than backward linkage. Rubber sheets and block rubber (095), tyres and tubes (096), and other rubber products (097) have more backward linkage than forward.

The total linkage index calculation indicates that the rubber sector (016) distributes more output to other sectors than the average distribution of all sectors. Rubber sheets and block rubber (095), tyres and tubes (096), and other rubber products (097) have more receiving factors from other sectors than the average of all sectors (see Table 2).

Table 1 Direct linkage of the rubber industry

I-O Code	Sector	Direct Backward Linkage (DB)			Direct Forward Linkage (DF)		
		Total Intermediate transaction of factors (Million baht)	**Value of total factor demand (Million baht)**	**Linkage (%)**	**Total Intermediate Transaction of Outputs (Million baht)**	**Value of Total Output Demand (Million baht)**	**Linkage (%)**
016	Rubber	55,249.13	310,310.47	17.80	143,173.69	310,310.47	46.14
095	Rubber sheet and block rubber	149,045.43	217,176.99	68.63	43,706.12	217,176.99	20.12
096	Tyres and tubes	57,237.06	105,795.96	54.10	46,109.96	105,795.96	43.58
097	Other rubber products	23,337.61	40,705.30	57.33	13,684.38	40,705.30	33.62
Total		**284,869.23**	**673,988.71**	**42.27**	**246,674.15**	**673,988.71**	**36.60**

Table 2 Total linkage index of the rubber industry

I-O Code	Sector	Total Backward Linkage (TB)	Total Forward Linkage (TF)
016	Rubber	0.71	1.28
095	Rubber sheet and block rubber	1.08	0.98
096	Tyres and tubes	1.09	0.80
097	Other rubber products	1.09	0.67
Average of total linkage in rubber industry		0.99	0.93

3) Thai rubber cluster identification and cluster map

According to the results of economic linkage analysis, the data used to identify the economic sectors to be included in the rubber cluster is then applied to create the rubber cluster map (Objective 2). The criteria for selecting the related sectors in the rubber cluster is as follows:
1) The total backward/forward linkage coefficients are more than the average of all sectors.
2) The transaction value is more than 400 million baht.
3) The cumulative percentage of the total intermediate output transactions is more than 95 per cent.
Hence, the results show that the rubber sectors have a backward linkage to 27 sectors with a direct backward index of 42.27 per cent and a forward linkage to 21 sectors with a direct forward index of 36.60 per cent (see Figure 2).

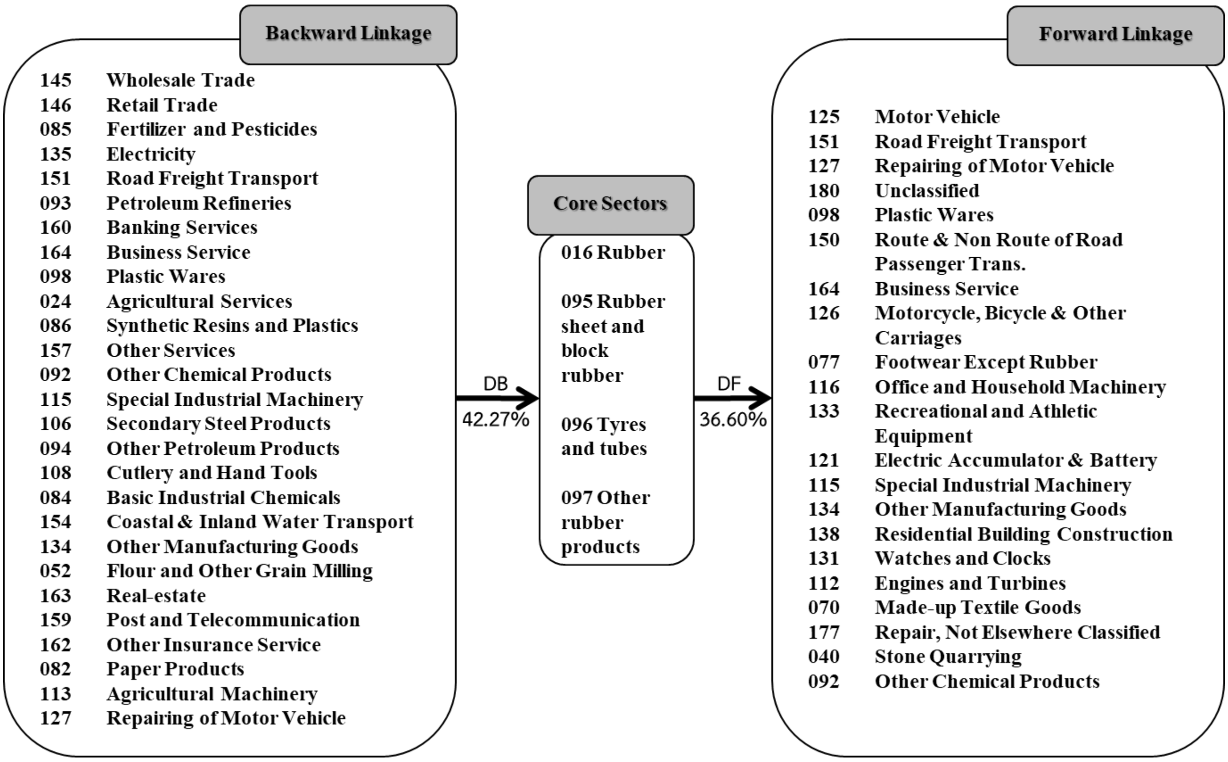

Figure 2 Economic linkage in the rubber industry

Figure 3 illustrates Thai rubber cluster mapping of economic linkage in the rubber industry, the concept of cluster mapping according to the International Trade Department of The World Bank (2009: 14-17; Danuvasin, 2017: 2-3), and information on Thai rubber cluster policies. The four core sectors are rubber, rubber sheets and block rubber, tyres and tubes, and other rubber products. Therefore, the sectors with backward linkage can be divided into four groups: 1) raw materials, 2) machinery and equipment, 3) business supporters, and 4) infrastructure, while the forward linkage sectors can be divided into five groups: 1) automotive, 2) houseware, 3) services, 4) transport, and 5) other. The supporting institutions in the cluster are government entities such as the Rubber Authority of Thailand, Ministry of Industry, Ministry of Commerce, universities, and research institutes. The supporting organisations consist of groups of rubber firms producing the same products or related business associations.

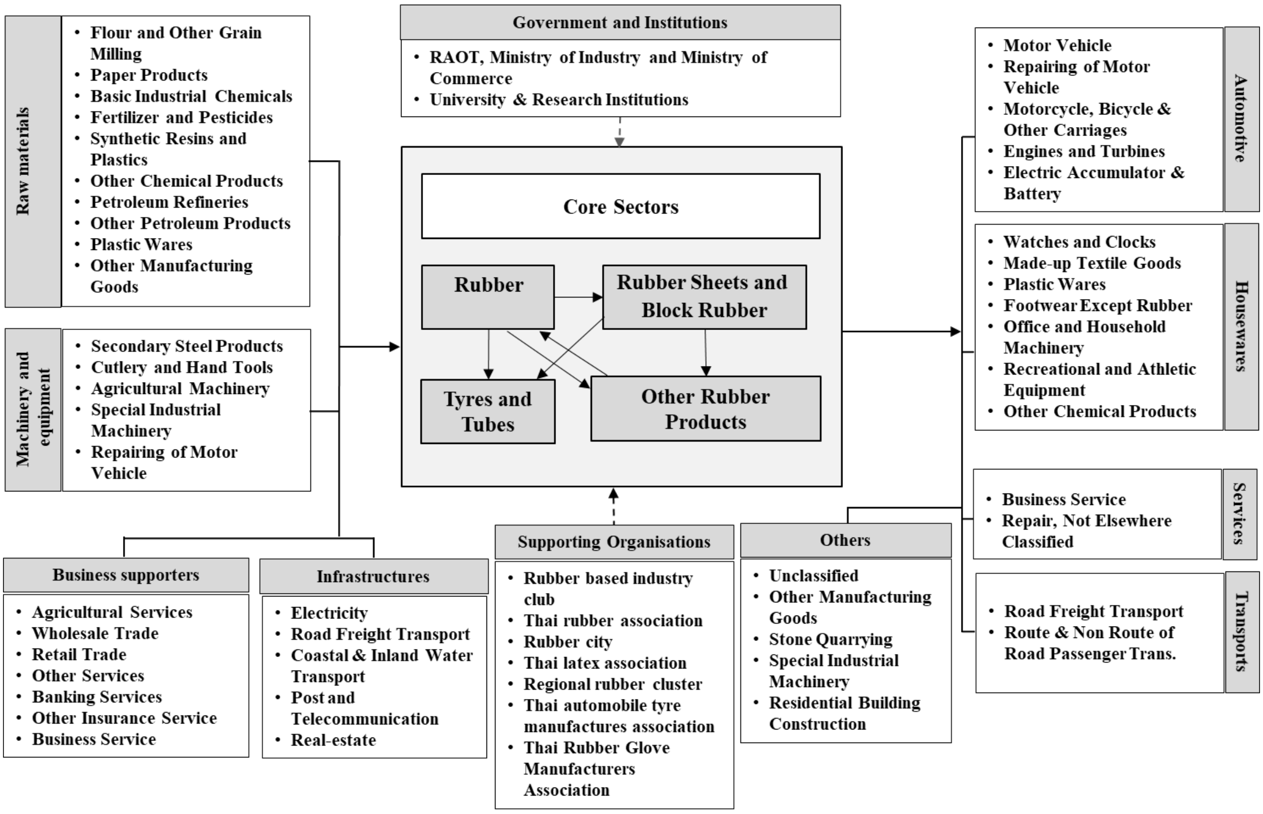

Figure 3 Thai rubber cluster map based on input-output analysis

Conclusion and Discussion

The industrial cluster has a crucial role to play in promoting industry development, especially in the Thai rubber industry which is faced with various problems. Hence, this research aims to promote the rubber cluster policy by analysing the economic linkage in the Thai rubber industry and identifying Thai rubber clusters as well as creating a rubber cluster map. The main technique applied in this research is input-output analysis, in similarity to Lublinski (2002: 39), Durcova (2018: 863), and Wangkahart (2011: 37-44). The advantage of this method is that it provides clarity in the calculation process and identifies the relevant sectors in the cluster from the economic structure, not merely by considering spatial concentration.

The results of this study show that Thai rubber industries have more backward linkage (TB > 1) than forward linkage since most raw rubber output is exported to produce final products in foreign countries, especially rubber sheets and block rubber. This study differs from the previous studies by Titze, Brachert, and Kubis (2011: 89-102), Duque and Rey (2008: 41-68), Duque, Rey, and Gomez (2009: 15-44) in that the dimensions of the analysis are specific to core industries. Therefore, the industrial cluster concept can be used to stimulate industry cooperation. It can create a relationship between stakeholders, and provide government support to facilitate a rise in productivity, competitiveness, and export performance (Sirisuwat, and Jindabot, 2012: 195-200). Clusters can create innovative new products/processes to increase the distribution of rubber output in the economy. From the rubber cluster map, it can be seen that rubber sectors relate to many industries in the Thai economy since the country is the largest producer of rubber and it can be used to produce various final products. Therefore, if rubber cluster promotion policies are successful, they will create a positive direct and indirect effect on related sectors. Consequently, the Thai government can utilise the results of the cluster map as a guide to promote the country's rubber cluster policies to create knowledge, innovation, and new business (Porter, 2007: 3).

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