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Spatial Patterns of Manufacturing Agglomeration in Cambodia, Lao People's Democratic Republic, and Thailand*

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Abstract: *Due to lowering trade and transport costs, participation in the global value chains (GVCs) is becoming one of the most effective development strategies for many developing countries. Participation in the GVCs, however, is not sufficient; the formation of industrial linkages and clusters is critical for sustained economic growth. This paper identifies the manufacturing clusters in Cambodia, the Lao People's Democratic Republic, and Thailand, using the method proposed by Mori and Smith (2013). The paper provides a map of industrial clusters by industry, which is tested against the hypothesis of spurious clusters. Moreover, the paper indicates the spatial structure of industrial agglomerations using the global extent and local density indices.*

Keyword: industrial agglomeration, cluster analysis, Lao People's Democratic Republic, Cambodia, Thailand

JEL Classification: L60 R12 R14

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1. Introduction

Industrial development and technological progress of the latecomer countries differ from those of the current developed countries. The former can move up the technology ladder by participating in the global value chains (GVCs) and utilizing linkages with multinational firms that seek lower production costs or new markets and that organize the GVCs: Local firms in the latecomer countries can learn and upgrade their technological capability through technology transfer from the multinational firms.

The above development strategy has become increasingly relevant because trade liberalization and economic integration offer increased opportunities for latecomer countries to participate in the GVCs of multinational firms, while the shrinking policy space, which was also caused by trade liberalization, has made infant-industry protection by the latecomer countries increasingly difficult to implement.

However, participation in the GVCs is not sufficient. Structural transformation, in particular industrial deepening—the formation of local linkages by creating a robust supplier base and expanding ancillary services (ADB 2013)—is necessary. To put it another way, the formation of industrial linkages and clusters is critical for sustained economic growth. This is because if the supplier industries are nurtured and developed within an industrial cluster, it will increase the competitiveness of the assembly industries by delivering parts and components at lower cost, in a shorter time, and with more flexibility (the 'forward linkage' effect). At the same time, the development of assembly industries provides intermediate demand for supplier industries that stimulates the development of upstream industries in sequence from the part and component suppliers to the raw material and machinery manufacturers (the 'backward linkage' effect). Such cumulative circular effects induce the formation of industrial clusters and enhance the competitiveness of the relevant industries.

Cambodia and Lao People's Democratic Republic (Lao PDR) have joined the GVCs of labour-intensive industries, especially the apparel and footwear industries, after they started to liberalize trade and investment in the 1990s. In particular, the normalization of relations with the Western countries and the generalized system of

preferences status offered by them helped Cambodia and Lao PDR participate in the GVCs.

However, since the early 2010s, more technologically sophisticated industries such as electronics, automobile parts, and precision machinery started to move to Cambodia and Lao PDR as a result of rising labour costs in the neighbouring countries, especially the People's Republic of China (PRC) and Thailand—as well as declining trade and transport costs encouraged by infrastructure development and trade liberalization in the Greater Mekong subregion.

As industrial development in Cambodia and Lao PDR is still in an early stage, priority should be placed on joining the GVCs in a greater variety of industries. However, in the next phase of industrial development, the formation of industrial clusters will become an important item on the policy agenda because they need to strengthen the competiveness of industry to offset rising labour and congestion costs.

In Thailand, import substitution industries, such as automobiles and household electrical appliances, attracted significant foreign direct investment in the 1960s, especially from Japan. However, Thailand changed its policy orientation and became actively involved in the GVCs organized by multinational firms after the mid-1980s, when there was a surge in investment from Japan and the East Asian countries such as Korea, Taiwan, and Hong Kong. As Thailand has a longer experience of industrial development and has implemented protective measures such as higher trade barriers and local content requirements, which were later prohibited by the current World Trade Organization rules, it is no surprise that Thailand's economy has established more robust local supplier bases than latecomer countries such as Cambodia and Lao PDR. However, local supplier bases in Southeast Asia—including Thailand, Malaysia, Indonesia, and the Philippines—are weaker than those in Northeast Asia—China, Japan, and Korea (Kuroiwa, 2015).

Against this backdrop, this paper identifies the manufacturing clusters in Cambodia, Lao PDR, and Thailand, using the method proposed by Mori and Smith (2013). Although the reasons for agglomerations—such as input–output linkages, labour pooling, and knowledge spillovers—cannot be identified by this method, it is of great importance to investigate the cluster patterns of the manufacturing industries in these economies. As discussed below, Mori and Smith provide a map of industrial

clusters by industry, which was tested against the hypothesis of spurious clusters. Moreover, Mori and Smith indicate the spatial patterns of industrial agglomerations using the global extent (GE) and local density (LD) indices. Note that these spatial patterns are extremely helpful as the industrial clusters often spread over a wider geographical area and as the GE and LD indices—along with the cluster mapping—display how the respective clusters fit into specific spatial patterns.

This paper is organized as follows. Firstly, the theoretical background of the method applied in this study is explained. Secondly, the empirical results are presented in the sequence of Cambodia, Lao PDR, and Thailand. Finally the paper concludes with a summary of the findings.

2. Two Indices for Identifying the Spatial Scale of Industrial Agglomeration

This section introduces the role and meaning of the two indices introduced by Mori and Smith (2013), as well as the method to derive the two indices and the way the values of these indices in this study are actually calculated.

2.1. The Method to Derive the Two Indices in Mori and Smith (2013)

The index developed by Mori and Smith (2013) was intended to identify the *spatial structure* of industrial agglomeration. For example, the spatial structure in which firms agglomerate at the global (i.e. large spatial) scale but disperse at the local (i.e. small spatial) scale may be observed, whereas the spatial structure in which firms disperse at the global scale but agglomerate at the local scale may also be seen. Using any single index faces the limitation of discerning such difference of spatial structure. Thus, two indices—GE and LD—were introduced by Mori and Smith (2013).

The process for deriving GE and LE can be divided into three steps: the clusters are detected, the essential containment is found, and the GE and LD are calculated.

The first step is to find cluster scheme $\mathbb{C}^*$ with a maximum value of Bayes information criteria (BIC) among each candidate cluster scheme:

$$BIC_{\mathbb{C}} = L_{\mathbb{C}}\left(\hat{P}_{\mathbb{C}}\middle|x\right) - \frac{k_{\mathbb{C}}}{2}\ln n$$

where

$$L_{\mathbb{C}}\left(\hat{P}_{\mathbb{C}}\middle|x\right) = \sum_{j=0}^{k_{\mathbb{C}}} n_j(x)\, ln\hat{p}_{\mathbb{C}}(j) + \sum_{j=0}^{k_{\mathbb{C}}} \sum_{r \in C_j} n_r\, ln\frac{a_r}{a_{C_j}}.$$

Cluster scheme $\mathbb{C}$ is simply one or more disjoint clusters, C_j , j= 1, … , k, and the residual set of all non-cluster regions. BIC increases with the larger log-likelihood of $\hat{P}_{\mathbb{C}}$, the location probability of cluster scheme $\mathbb{C}$ for each basic region**,** given an observed location pattern x, whereas BIC decreases with the penalty term composed by $k_{\mathbb{C}}$, which expresses the number of clusters in a cluster scheme $\mathbb{C}$**,** and n, which expresses the number of establishments in the total area.

The location probability of cluster scheme $\mathbb{C}$ for cluster j= 1, … , k, $p_{\mathbb{C}}(j)$, which can be rewritten as $\hat{p}_{\mathbb{C}}(j) = n_j(x)/n$ where $n_j(x)$ expresses the sum of the number of establishments in cluster j= 1, … , k and n expresses the total number of establishments in the whole regions. In the above log-likelihood functions, $n_j(x)$ and n_r are related with a sequence of independent location decisions by individual establishments. Because each region is included as part of a certain cluster C_j, j= 1, … , k or the residual set of all non-cluster regions, the right hand-side of the log-likelihood function of the location probabilities (i.e. a probability that a randomly sampled establishment locates in a region within a certain cluster) expresses the law of total probability: the log-likelihood function can be divided into two parts, namely the first term, which gives the location probabilities that n_j establishments locate in a cluster C_j, j= 1, … , k, and the second term, which gives the location probability that n_r establishments locate in region r in cluster C_j, j= 1, … , k, given that individual establishments choose their location completely randomly within each cluster. In the process of choosing an additional region within a cluster, the shortest path distance is used.

The second step is divided into two parts. The first part is to find the essential clusters, which are the most significant clusters in terms of incremental contributions to BIC under the condition that the sum of incremental contributions to BIC exceeds a certain proportion (λ) of $BIC_{\mathbb{C}}$, The last part of the second step is to find the smallest convex-solid set in the total area containing the set of essential clusters. Intuitively, a

convex-solid set means that the set is connected and has not only no dents in its perimeter but also no internal cavities. Then, the regions in the smallest convex-solid set can be regarded as an essential containment.

Finally, we can obtain the GE for an industry by dividing the total economic area of essential containment for an industry by the total economic area of the whole country. Likewise, we can obtain the LD for the industry by dividing the total economic area of the essential clusters for the industry by the total economic area of the essential containment.

2.2. A Test of Spurious Clusters

The recent trend in the index of industrial agglomeration is to implement the test against 'the null hypothesis' that spatial distribution could simply have emerged by chance (Ellison and Glaeser, 1997; Duranton and Overman, 2005; and Mori, *et al.*, 2005). In Mori and Smith (2013), a test of spurious clusters was conducted to test whether the BIC of the best cluster scheme is significantly better than that under a random location pattern generated by a Monte Carlo test.

2.3. The Derivation of Global Extent and Local Density on Three Countries

To obtain GE and LD on Cambodia, Lao PDRs and Thailand, we have applied the above-mentioned method to the data on these countries with respect to distance, economic area, and the number of establishments.[1] The distances are calculated by the direct line between the centroid of each region in the shape files instead of road network distance. The shape files for Lao PDR and Cambodia were Global Administrative Unit Layers produced by the Food and Agriculture Organization of the United Nations. The shape files for Thailand were downloaded from DIVA-GIS (diva-gis.org). The economic areas are obtained from the Global Land Cover 2000 by the Joint Research Center of the European Commission. Omitting any area that is not suitable for economic activity, we calculated the economic area of each region using the shape files. The explanation about the establishment data is in the following

[1] The computer programs for these analyses introduced by Mori and Smith (2013) are available at http://www.mori.kier.kyoto-u.ac.jp/data/cluster_detection.html.

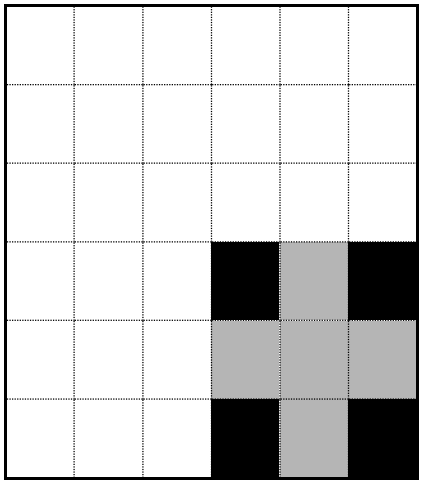
sections. Finally, we have chosen the value of λ appropriately, following the recommendation by Mori and Smith (2014).

2.4. The Role and Meaning of the Two Indices by Mori and Smith (2013)

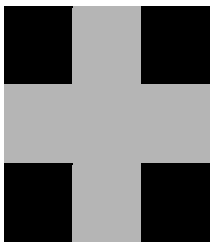
The combination of GE and LD reflects the *spatial structure* of industrial agglomeration because the value of GE indicates the share of the total area of essential containment (black and grey squares in Figure 1-1), which is the smallest convex-solid set containing the set of essential clusters, relative to that of the entire country (the entire area in Figure 1-1). The value of LD expresses the share of the total area of its essential clusters (black squares in Figure 1-2) relative to that of its essential containment (black and grey squares in Figure 1-1).

Figure 1: Calculation of Global Extent and Local Density

1. Calculation of Global Extent



2. Calculation of Local Density



Thus, a larger GE may represent the spatial distribution of an industry that is more dispersed throughout a country, whereas a larger LD may reveal the spatial distribution of an industry that is more dispersed throughout the essential containment. In other words, industries with a low GE are regarded as exhibiting a relatively ‘confined’ spatial pattern, while those with a high GE demonstrate a relatively ‘dispersed’ pattern.

Likewise, industries with a high LD indicate a relatively ‘dense’ pattern, while those with a low LD demonstrate a relatively ‘sparse’ pattern. Thus, we obtain four patterns of spatial structure, which are used in Section 3, namely the ‘globally dispersed and locally dense’ pattern; ‘globally dispersed and locally sparse’ pattern; ‘globally confined and locally dense’ pattern; and ‘globally confined and locally sparse’ pattern.

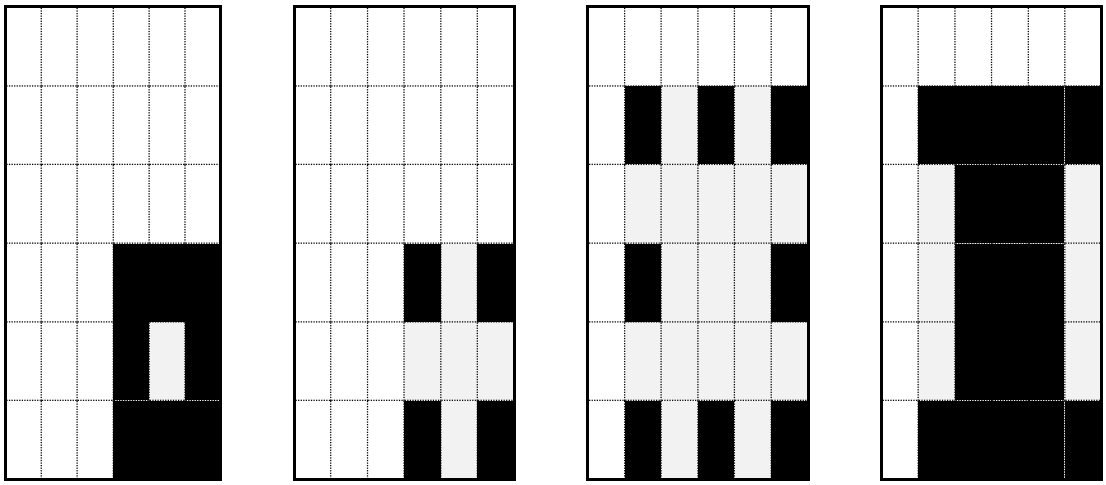
To get a clearer image of the four patterns of spatial structure, we exemplify the GE and LD using a box composed of 36 blocks. We obtain the four simplified figures for the GE and LD for each pattern in Figure 2, and setting λ is 1 for simplicity. Each of the four boxes has 36 blocks, which implies there are 36 regions in the entire country. The number of black and grey regions is used to calculate the GE and LD. The black regions show the regions in an essential cluster. The grey regions are not regarded as essential clusters but as regions in the essential containment.

The first figure in Figure 2 is for the globally confined and locally dense pattern. From the number of regions of the total area, the essential containment and essential cluster are respectively 36, 9, and 8, we calculate the GE as 9/36=0.25 and LD as 8/9=0.89. In the same manner, we can obtain the GE and LD for the other three spatial structure patterns.

Notice the difference in the number of regions in the essential clusters between the first and the third figures. The usage of GE and LD clarifies the differences in *spatial structure*.

Figure 2: Four Combinations of Global Extent and Local Density

(1) Globally confined and locally dense pattern	(2) Globally confined and locally sparse pattern	(3) Globally dispersed and locally sparse pattern	(4) Globally dispersed and locally dense pattern
GE = 0.3, LD = 0.9	GE = 0.3, LD = 0.4	GE = 0.7, LD = 0.3	GE = 0.7, LD = 0.8



Note : GE = global extent, LD = local density.

3. Empirical Results

This section introduces the empirical results of the analyses on spatial patterns of manufacturing agglomerations that were introduced in Section 2. The section is separated into three subsections, namely for Cambodia, Lao PDR, and Thailand.

3.1. The Case of Cambodia

This study uses the Economic Census data of Cambodia for 2011. The data covers 70,355 manufacturing firms. In the following section, the cluster patterns of the most

significant industries in Cambodia are discussed. Then follow the four location patterns of manufacturing agglomeration in Cambodia that were introduced in the previous section.

3.1.1 Cluster Patterns of Significant Industries

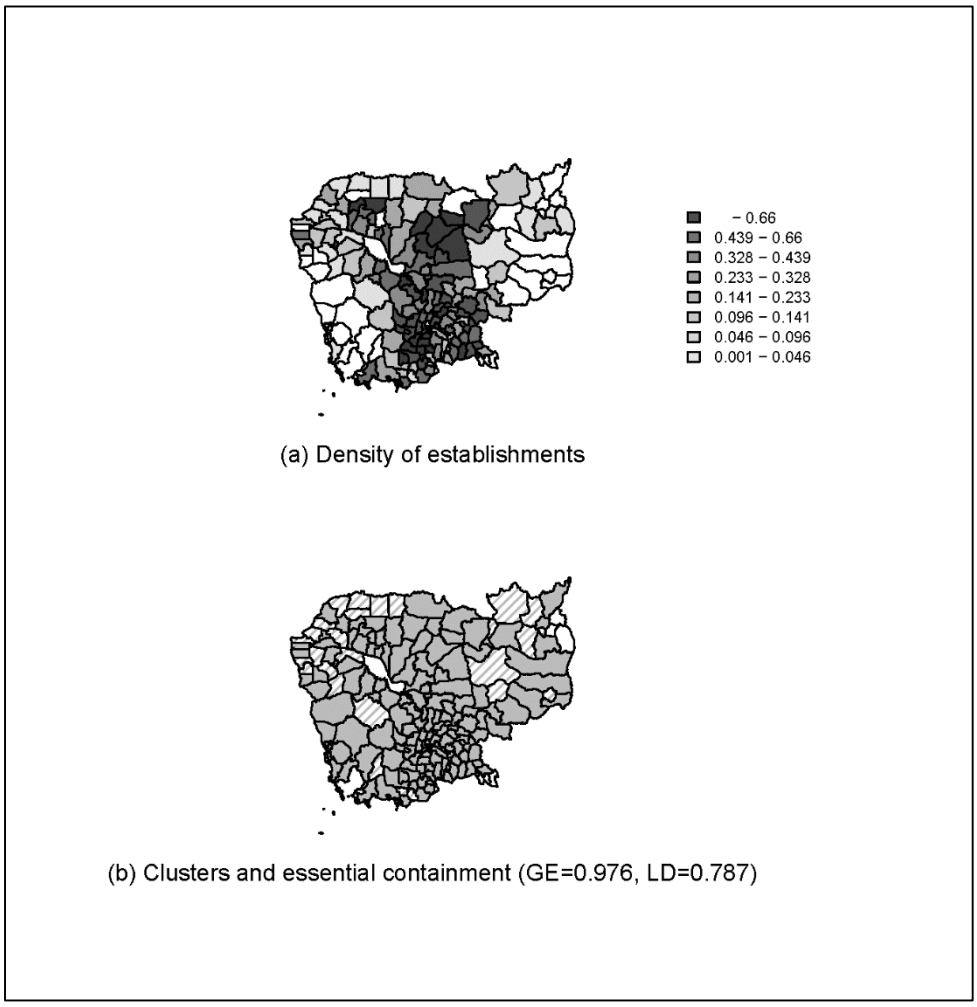
Table 1 indicates the industry ranking in Cambodia in terms of the number of establishments, number of employees, and firm size (i.e. the average number of employees per firm).

First, Table 1 shows that grain mill product (ISIC 1061) is the most significant sector in terms of the number of establishments: it is simultaneously the second largest sector in terms of the number of employees. It should be noted that, as shown in Figure 3.1-1, grain mill product clusters are spread across the country, and its GE (0.976) and LD (0.787) are also significantly high (see also Figure 3.1-4). Since paddy and other grain fields, as well as the consumers of these products, are spread all over the country, it is no wonder that the various locations of grain mill product are quite ubiquitous, except for non-economic areas such as the mountain, lake, and river areas.

Table 1: Significant Industries in Cambodia

	Name of Industry	Number of Establishments	Name of Industry	Number of Employees	Name of Industry	Number of Employees per Establishment
1	Grain mill products	19,476	Wearing apparel (except fur)	280,192	Footwear	362
2	Wearing apparel (except fur)	15,600	Grain mill products	40,579	Finishing of textile	343
3	Weaving of textile	8,504	Footwear	37,963	Knitted and crocheted fabrics	269
4	Sugar	6,114	Weaving of textile	31,997	Plastics and synthetic rubber in primary forms	267
5	Distilling, rectifying, and blending of spirits	4,069	Sugar	15,458	Malt liquors and malt	160

Figure 3.1-1. Manufacture of Grain Mill Products (1061): Cambodia

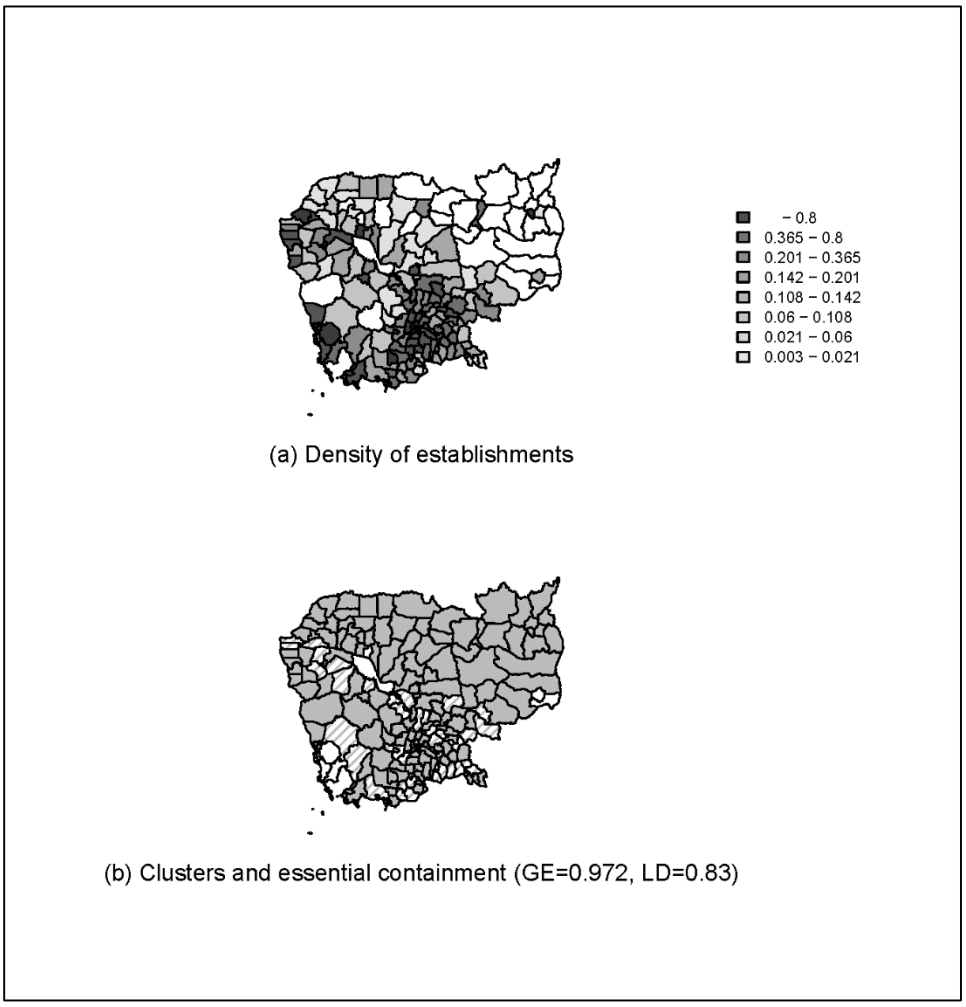


Note : GE = global extent, LD = local density.

Table 1 shows that wearing apparel, except fur (ISIC 1410), is the largest (the second largest) sector in terms of the number of employees (in terms of the number of establishments). As shown in Figure 3.1-2, this sector is quite ubiquitous with high GE (0.972) and LD (0.830). Note that major investors in this sector are foreign firms, especially in terms of the volume of exports. Foreign firms were located in Phnom Penh and its suburbs. However, in recent years foreign firms, as well as local firms, have spread their investment across a wider area.[2]

[2]Note that small local establishments, which manufacture traditional clothing, are located across the country, including in rural areas.

Figure 3.1-2: Manufacture of Wearing Apparel, Except Fur (1410): Cambodia

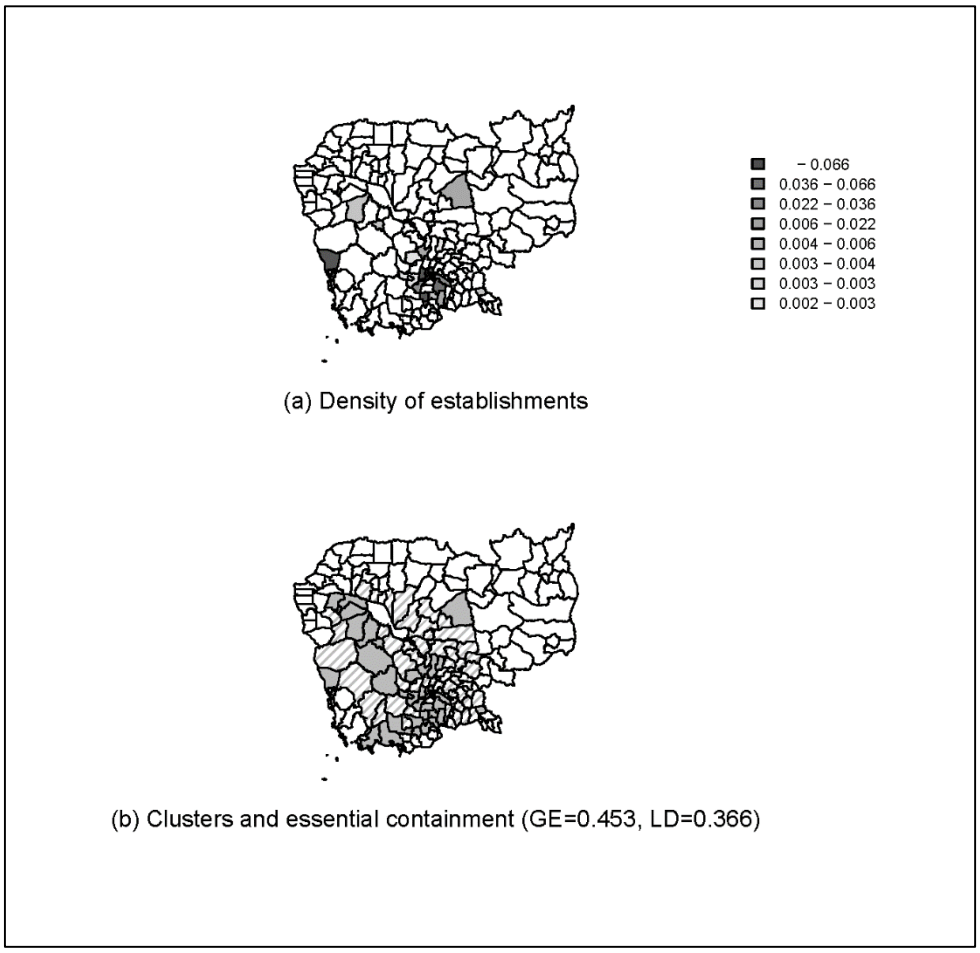


Note : GE = global extent, LD = local density.

Table 1 shows that footwear (ISIC 1520) is the largest sector in terms of firm size (i.e. the number of employees per establishment). As with wearing apparel (except fur), the footwear industry has attracted a large number of foreign investors and contributes to expansion of exports from Cambodia. However, the location pattern of footwear is totally different from that of wearing apparel (Figure 3.1-3). The number of establishments for footwear (105) is much smaller than that for wearing apparel (15,600), but the opposite is true in terms of the number of employees per establishment. However, unlike wearing apparel, the footwear establishments are concentrated in a small number of districts in the greater Phnom Penh area: note that

its GE (0.453) and LD (0.366) are also significantly lower than that of wearing apparel (see Figure 3.1-4).

Figure 3.1-3: Manufacture of Footwear (1520): Cambodia



Note : GE = global extent, LD = local density.

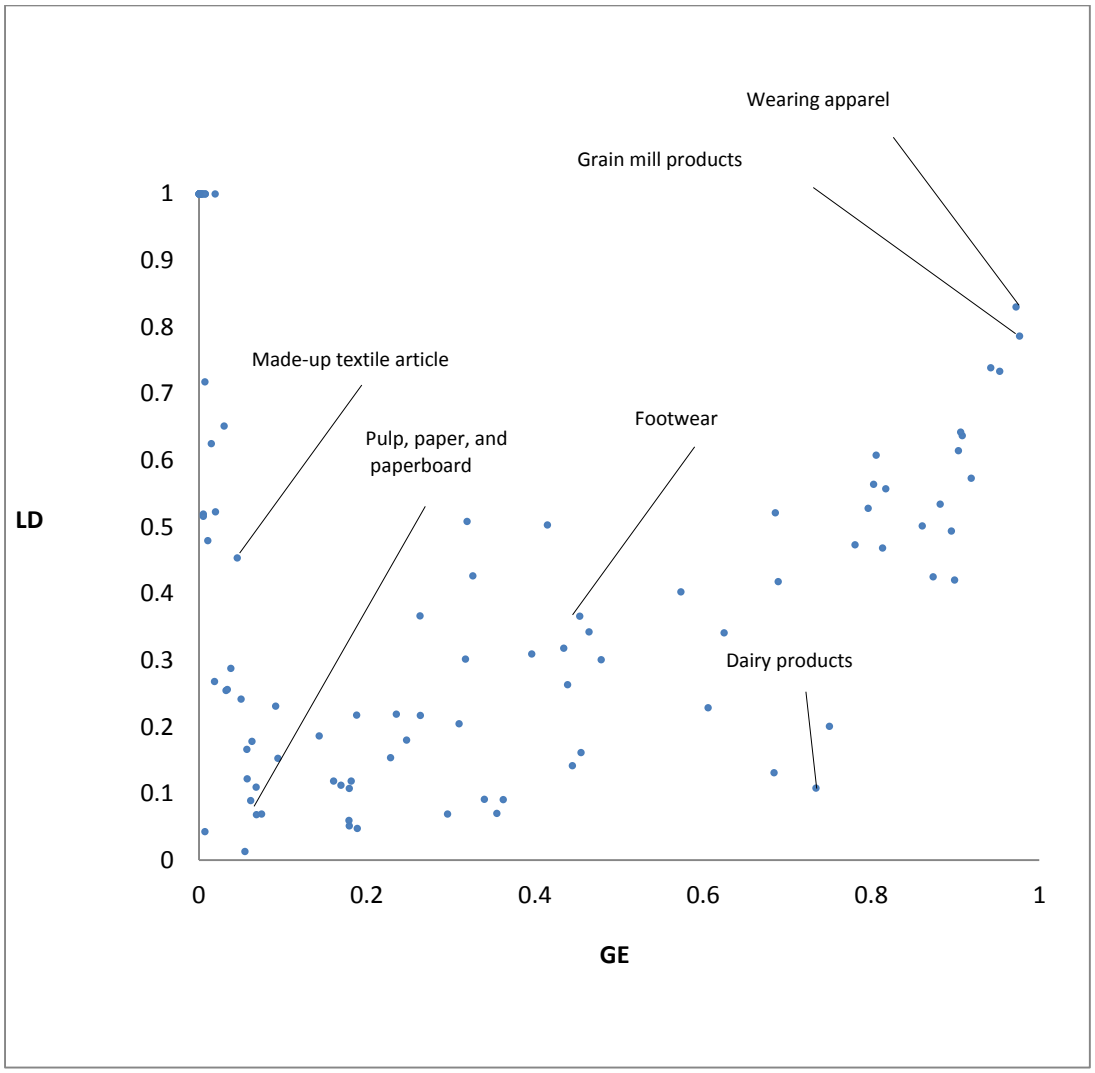
3.1.2 Four Location Patterns of Industrial Agglomerations

As discussed in the previous section, the GE and LD indices—and the combination of these two indices—indicate the spatial patterns of industrial agglomerations. In this subsection, the four location patterns of manufacturing agglomerations are demonstrated, in line with Mori and Smith (2013).

(1) Globally Dispersed and Locally Dense Patterns

Industries with relatively high values of GE and LD exhibit globally dispersed and locally dense patterns of industrial agglomeration. As discussed above, wearing apparel (except fur) and grain mill product—both of which are positioned near the northeast corner in Figure 3.1-4—are good examples of this pattern of industrial agglomeration. Note that these industries have a great number of establishments, and they are quite ubiquitous, except in non-economic areas.

Figure 3.1-4: Global Extent and Local Density in Cambodia, 2011

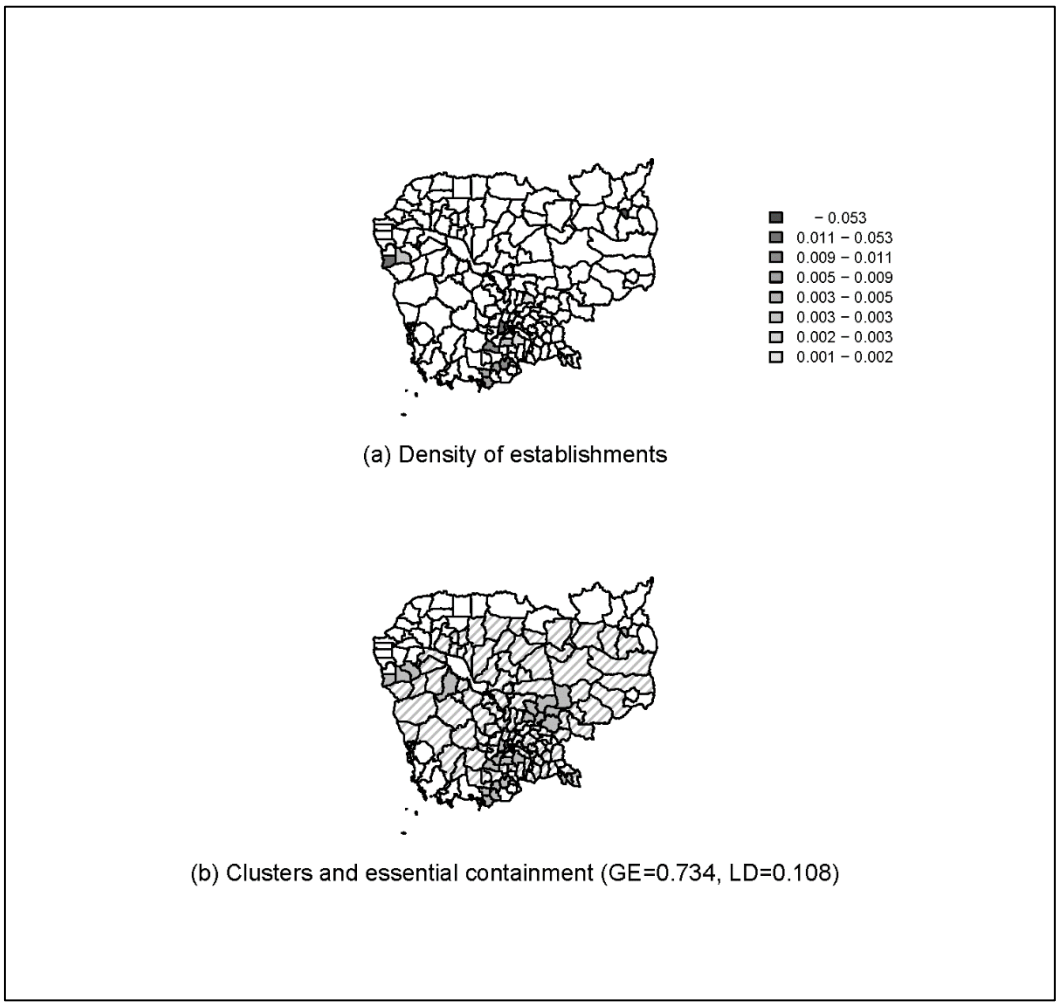


Note : GE = global extent, LD = local density.

(2) Globally Dispersed and Locally Sparse Patterns

Industries with relatively high values of GE and low values of LD—which are positioned near the southeast corner in Figure 3.1-4—exhibit globally dispersed and locally sparse patterns. A clear example of such a location pattern is provided by dairy products (ISIC 1050). As shown in Figure 3.1-5, the essential containment of dairy products is spread across a wider area, but the industrial clusters of dairy products are geographically sparse within the essential containment: in particular, they are concentrated in the suburbs of Phnom Penh, as well as in a few districts near the national border.

Figure 3.1-5: Manufacture of Dairy Products (1050): Cambodia



Note : GE = global extent, LD = local density.

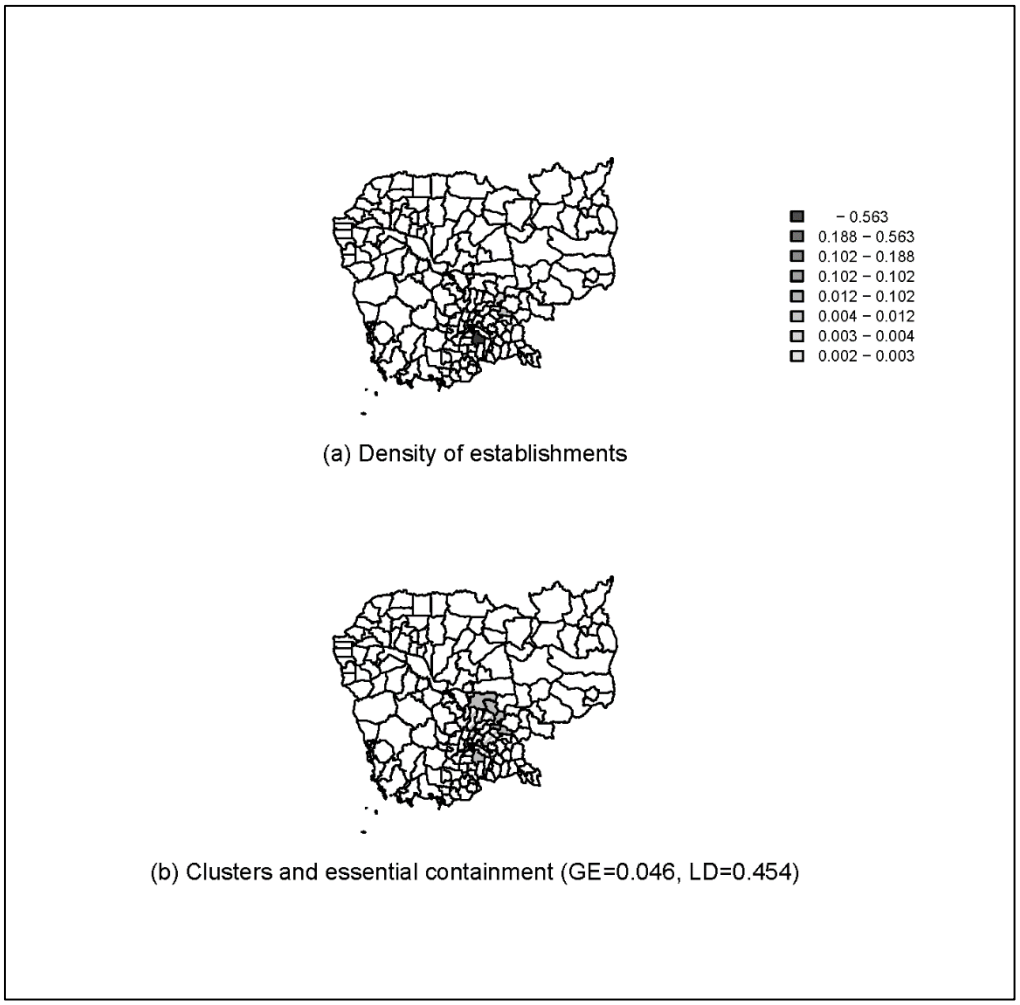
(3) Globally Confined and Locally Dense Patterns

Industries with relatively low values of GE and high values of LD―which are positioned near the northwest corner in Figure 3.1-4―exhibit globally confined and locally dense patterns. However, it should be noted that there are several industries whose values of GE are near zero and whose values of LD are all one. Many of these industries exhibit such an extreme location pattern because they contain only one establishment. It is clearly not appropriate to draw any conclusion on location patterns from such a small number of establishments, and thus they are dropped from the selections of location patterns.[3]

Figure 3.1-6 indicates the location patterns of made-up textile articles, except apparel (ISIC 1392). The industrial agglomerations are spread around Phnom Penh and its suburbs. The number of establishments for made-up textile articles is 322, but, as shown in Mori and Smith (2013), it is clear that industries with a small number of establishments tend to exhibit globally confined and locally dense patterns.

[3]There are many industries in Cambodia that have only a small number of establishments. Thus, there is always the possibility that some Cambodian industries are seemingly geographically concentrated not due to economies of scale in production or agglomeration externalities but rather due to immaturity in industrial development.

Figure 3.1-6: Manufacture of Made-Up Textile Articles, Except Apparel (1392): Cambodia

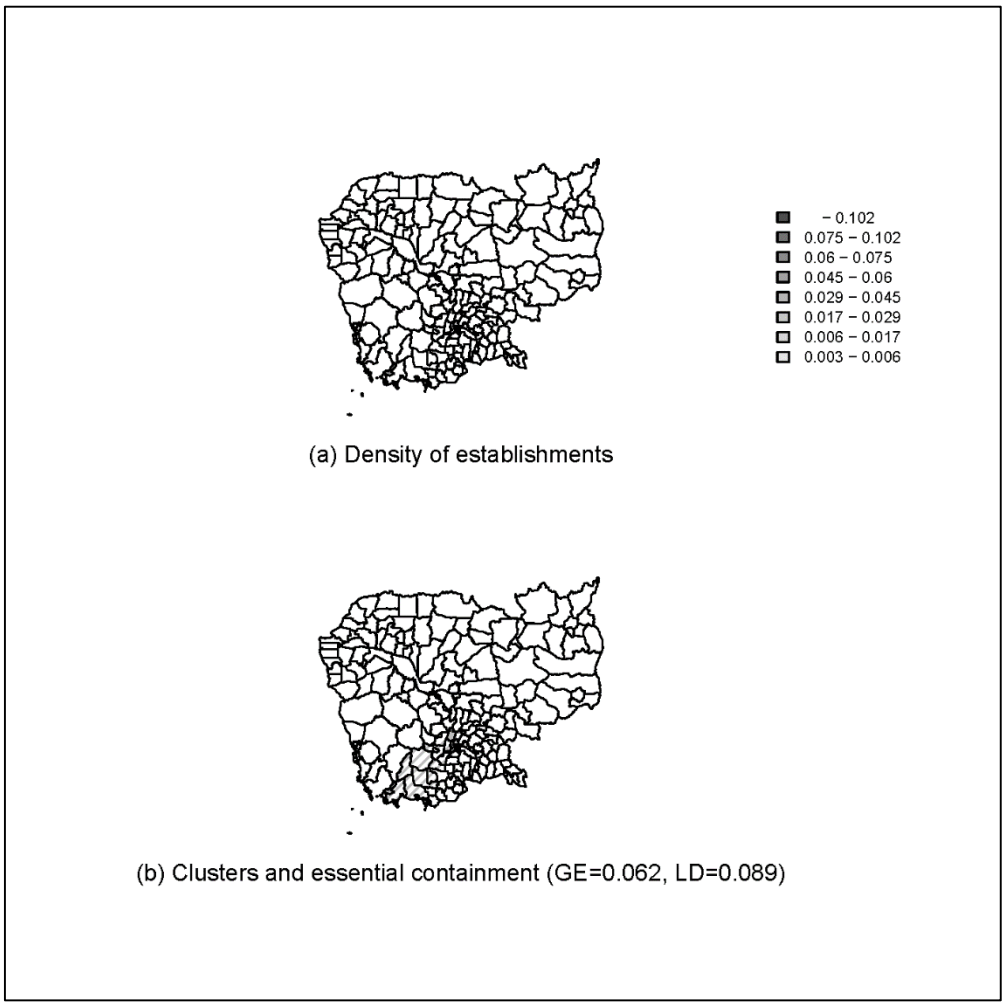


Note : GE = global extent, LD = local density.

(4) Globally Confined and Locally Sparse Patterns

Industries with relatively low values of GE and LD—which are positioned near the southwest corner in Figure 3.1-4)—exhibit globally confined and locally sparse patterns. A clear example of this location pattern is provided by the pulp, paper, and paperboard industry (ISIC 1701). As shown in Figure 3.1-7, the geographical extension of the essential containment is relatively narrow, and the industrial clusters of pulp, paper, and paperboard establishments are geographically sparse within the essential containment: mainly these clusters are located either in Preah Sihanouk Province or the Phnom Penh metropolitan area.

Figure 3.1-7: Manufacture of Pulp, Paper, and Paperboard (1701): Cambodia



Note : GE = global extent, LD = local density.

3.2. The Case of Lao PDR

The dataset used for the study of Lao PDR is the Economic Census for 2006. The data covers 126,913 establishments, among which 22,935 establishments (18 percent) are in the manufacturing sector categorized according to the Central Product Classification (CPC) 4 digit codes. Using the data for the manufacturing sector, the cluster patterns of significant industries as well as four location patterns of manufacturing agglomeration in Lao PDR with the GE and LD indices are demonstrated in the following subsections.

3.2.1 Cluster Patterns of Significant Industries

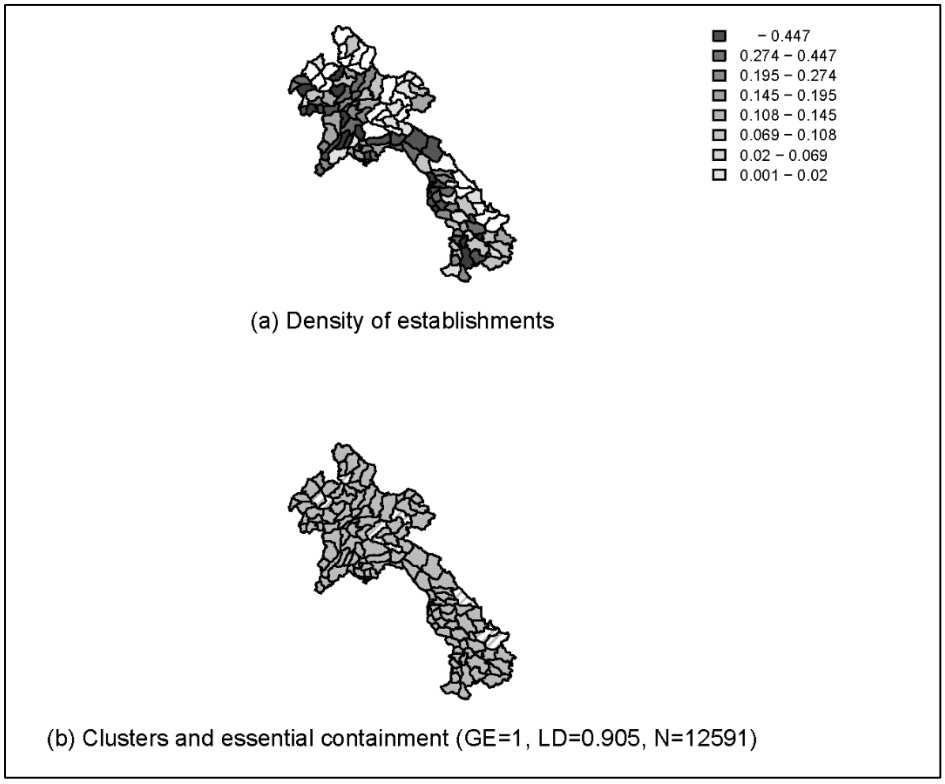
Table 2 indicates the industry rankings in Lao PDR in terms of the number of establishments, number of employees, and establishment size (i.e. the average number of employees per establishment).

Table 2 shows that rice milling (precisely, CPC 2316: rice, semi- or wholly milled, or husked) is the most significant sector in terms of the number of establishments: it is simultaneously the largest sector in terms of the number of employees. It should be noted that rice milling establishments are spread across the country, and the GE (1) and LD (0.905) are also significantly high (see also Figure 3.2-4). As in Cambodia, since the rice fields are spread across arable land and rice is the staple food of Lao PDR, it is not surprising that the locations of rice mills are quite ubiquitous.

Table 2: Significant Industries in Lao People's Democratic Republic

	Name of Industry	Number of Establishment	Name of Industry	Number of Employees	Name of Industry	Number of Employees per Establishment
1	Rice, semi- or wholly milled, or husked	12,591	Rice, semi- or wholly milled, or husked	280,192	Homogenized tobacco; tobacco extracts and essences	575
2	Woven fabrics of silk or of silk waste	1,314	Basket ware and wickerwork	40,579	Canned vegetables, pulses, and potatoes	300
3	Seats	1,124	Railway or tramway sleepers of wood, not impregnated	37,963	Garments made up of felt or nonwovens	284
4	Basket ware and wickerwork	740	Seats	31,997	Waterproof footwear	246
5	Spirits, liqueurs and other spirituous beverages	702	Bricks, blocks, tiles, and other ceramic goods of siliceous earths	15,458	Beer made from malt	244

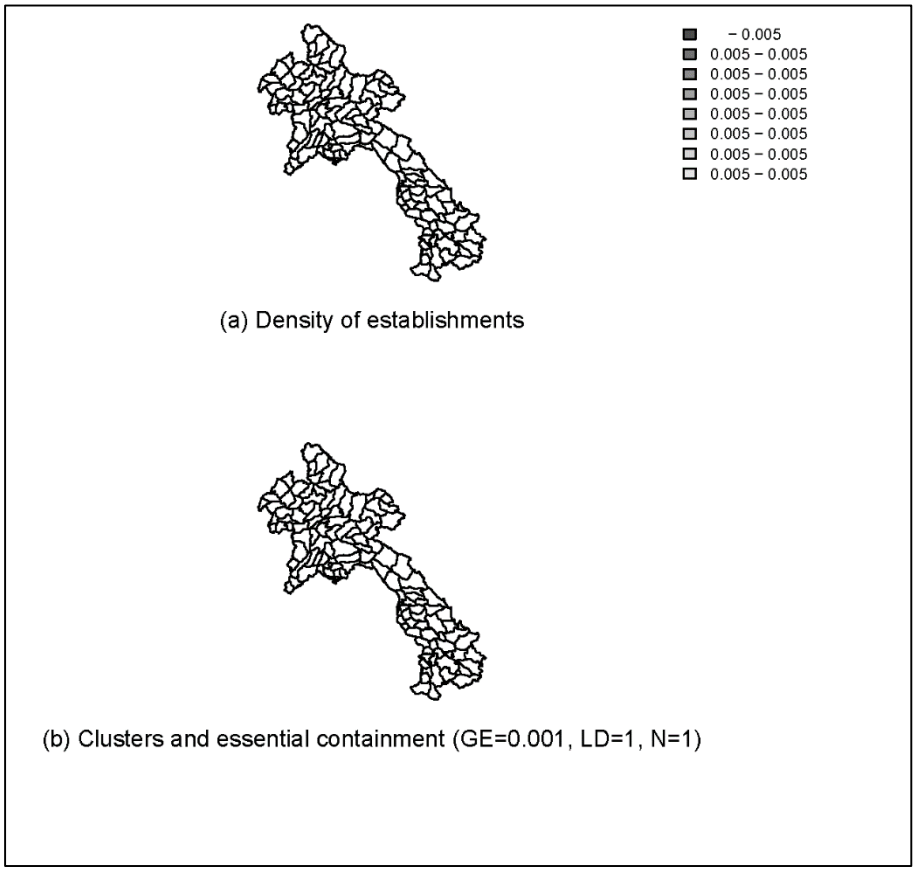
Figure 3.2-1: Rice, Semi- or Wholly Milled, or Husked (2316): Lao People's Democratic Republic



Note : GE = global extent, LD = local density.

Table 2 shows that tobacco products (CPC 2509: other manufactured tobacco and manufactured tobacco substitutes; homogenized or 'reconstituted' tobacco; tobacco extracts and essences) are the largest sector in terms of the average firm size (i.e. the number of employees per establishment). The location pattern for tobacco products is totally different from that of rice milling (see Figure 3.2-2), as one establishment, which may be state-owned, monopolizes the tobacco products sector, with 575 employees. This location pattern for tobacco products is in stark contrast with that for rice milling (12,591) that accounts for 55 percent of the manufacturing establishments in Lao PDR and employs 22 people on average per unit. Reflecting the existence of a single establishment for tobacco products, the GE (0.001) is significantly smaller than that for rice milling.

Figure 3.2-2: Other Manufactured Tobacco and Manufactured Tobacco Substitutes; Homogenized or 'Reconstituted' Tobacco; Tobacco Extracts and Essences (2509): Lao People's Democratic Republic



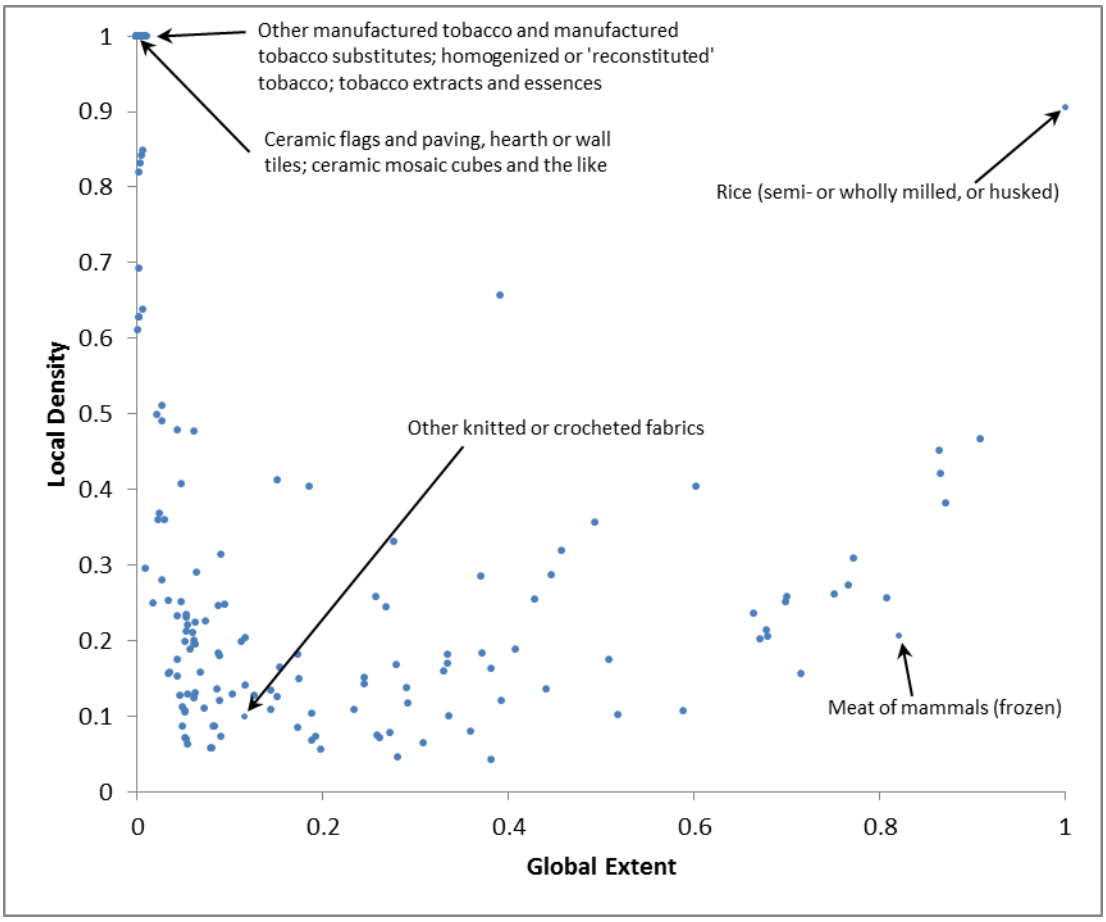
Note : GE = global extent, LD = local density.

3.2.2 Four Location Patterns of Industrial Agglomerations

(1) Globally Dispersed and Locally Dense Patterns

As discussed above, the rice milling (CPC 2316: rice, semi- or wholly milled, or husked) industry, which is positioned near northeast corner in Figure 3.2-3, is an example of a globally dispersed and locally dense pattern of industrial agglomeration. This industry has a great number of establishments and is quite ubiquitous except in non-economic areas as shown in Figure 3.2-1..

Figure 3.2-3: Global Extent and Local Density in Lao People's Democratic Republic, 2006

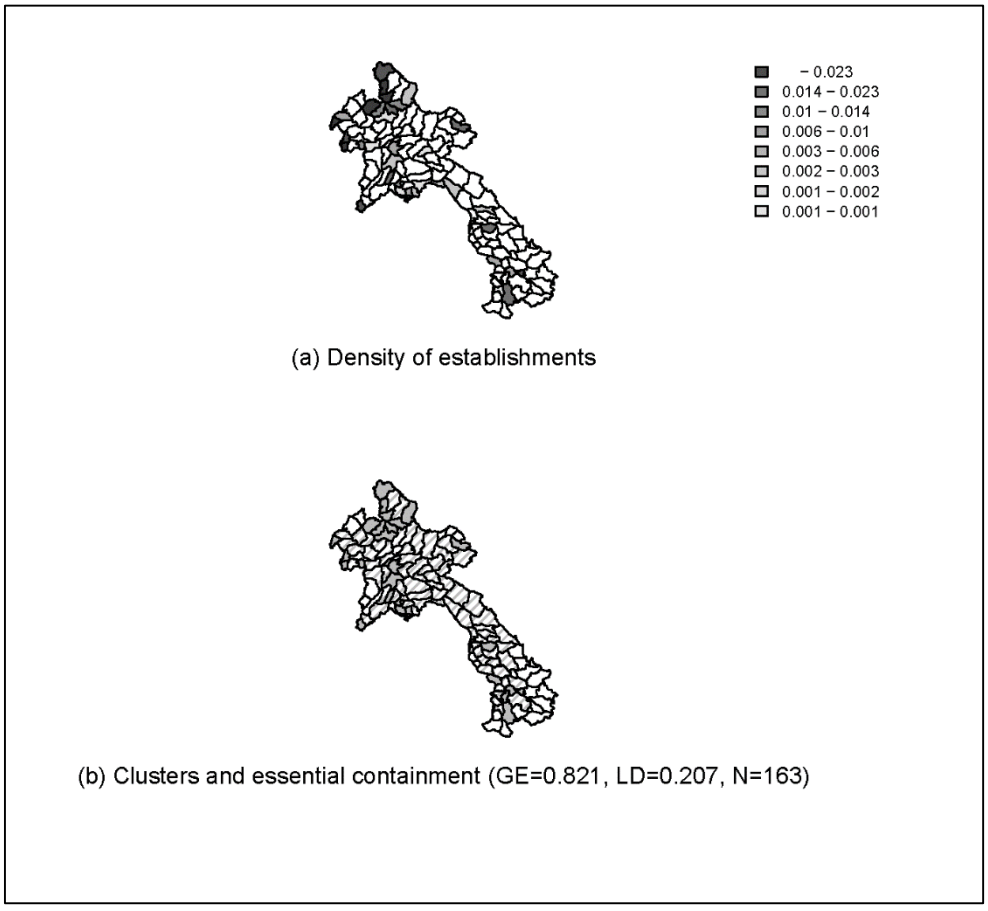


(2) Globally Dispersed and Locally Sparse Patterns

The frozen meat of mammals (CPC 2113) is an example of a globally dispersed and locally sparse pattern of industrial agglomeration. This industry has a relatively

high value of GE (0.821) and low value of LD (0.207), and positioned near the southeast corner in Figure 3.2-2. As shown in Figure 3.2-4, the essential containment of establishments dealing with frozen meat of mammals is spread across a wider area, but the industrial clusters of establishments dealing with frozen meat of mammals are geographically sparse within the essential containment. It is noteworthy that, compared to fresh or chilled meat of mammals (CPC 2111), whose GE and LD are respectively 0.865 and 0.451, the LD for frozen meat is considerably low.

Figure 3.2-4: Meat of Mammals, Frozen (2113): Lao People's Democratic Republic

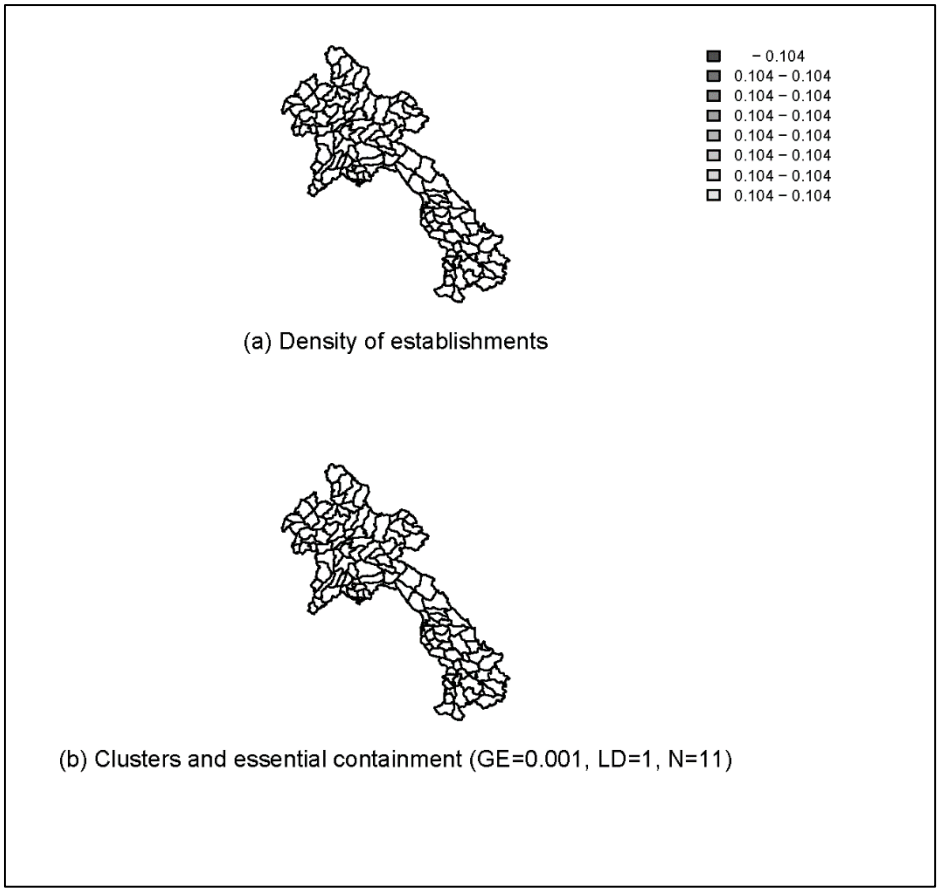


Note : GE = global extent, LD = local density

(3) Globally Confined and Locally Dense Patterns

The ceramic product sector (CPC 3737: ceramic tiles and paving, hearth or wall tiles; ceramic mosaic cubes and similar) is an example of a globally confined and locally dense pattern of industrial agglomeration in Lao PDR. This industry has a relatively low value of GE (0.00057) and high value of LD (1), and positioned near the northwest corner in Figure 3.2-2. Consistent with Mori and Smith (2013), it is clear that an industry with a small number of establishments exhibits a globally confined and locally dense pattern. Figure 3.2-5 illustrates that this industry, which has 11 establishments, is clustered only in Pakse and Champasak province.

Figure 3.2-5: Ceramic Flags and Paving, Hearth or Wall Tiles; Ceramic Mosaic Cubes and the Like (3737): Lao People's Democratic Republic

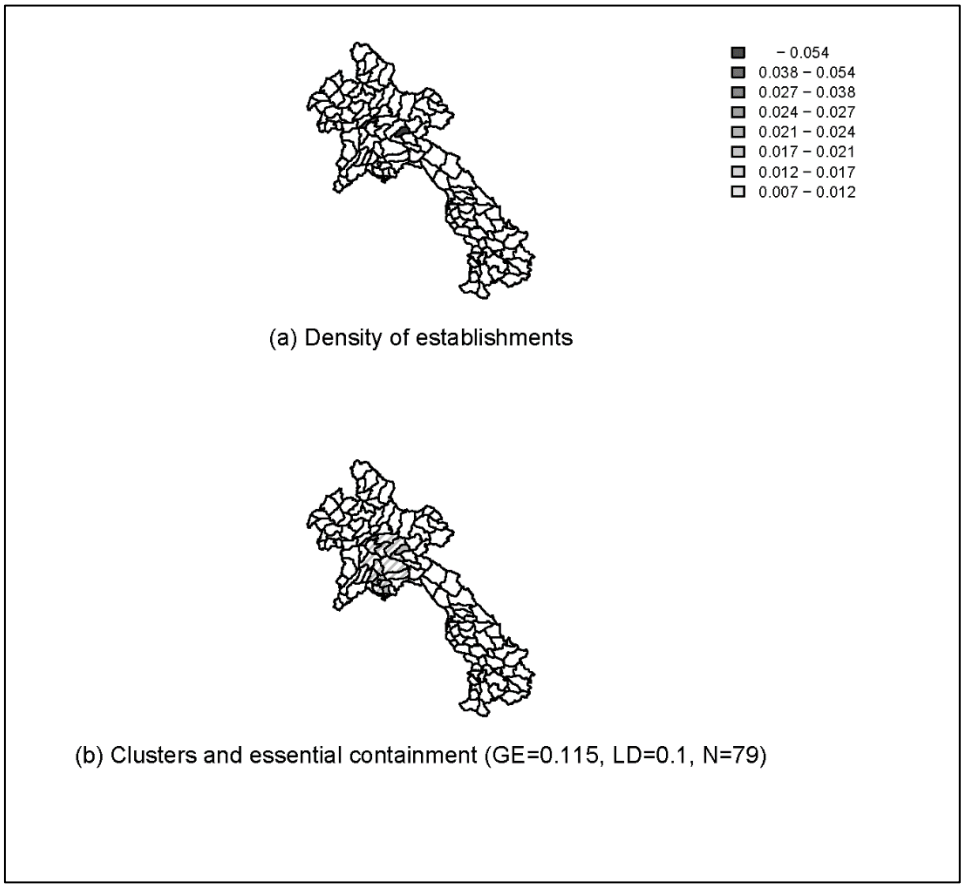


Note : GE = global extent, LD = local density

(4) Globally Confined and Locally Sparse Patterns

An example of globally confined and locally sparse pattern is other knitted or crocheted fabric products (CPC 2819) with relatively low values of GE (0.115) and LD (0.100). This industry is positioned near the southwest corner in Figure 3.2-3. Figure 3.2-6 illustrates a relatively extensive but confined area of essential containment, and the industrial clusters of other knitted or crocheted fabric establishments are geographically sparse within the essential containment. This may reflect the current situation where traditional fabric-related production, such as of silk, may spread across the country, while a modern fabric-related industry is located in the capital region.

Figure 3.2-6: Other Knitted or Crocheted Fabrics (2819): Lao People's Democratic Republic

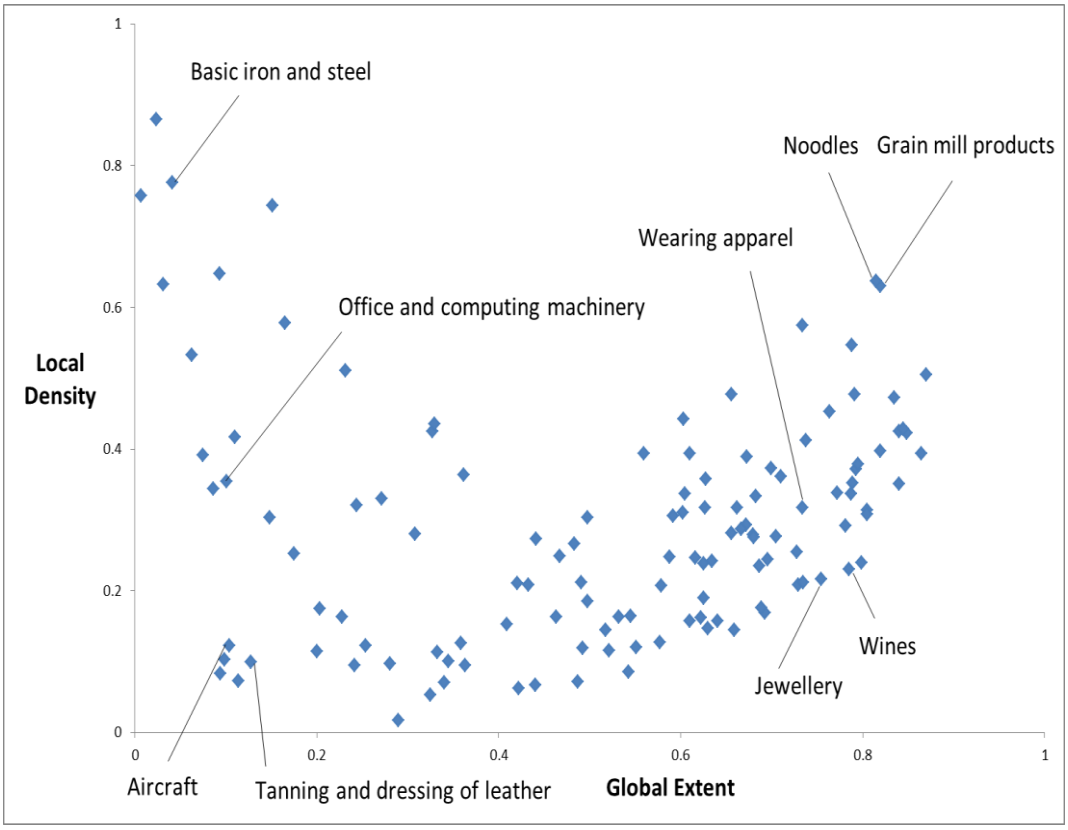


Note : GE = global extent, LD = local density

3.3. The Case of Thailand

The industrial census data of Thailand was for 2007. The data covers 73,931 manufacturing firms in 127 ISIC-Rev.3 sectors. Figure 3.3-1 shows the GE and LD values for these industries. It can be seen that most industries in Thailand exhibit a globally dispersed and locally sparse pattern of agglomeration as they have a moderate to high level of GE but low to moderate level of LD. In this section, we summarize the key findings of the agglomeration pattern of some of the most significant and interesting industries in Thailand.

Figure 3.3-1: Global Extent and Local Density in Thailand, 2007



3.3.1 Cluster Patterns of Significant Industries

Table 3 indicates the industry ranking in Thailand in terms of the number of establishments, number of employees, and firm size. The manufacture of wearing apparel (ISIC 1810) is the largest industry in Thailand in terms of the number of establishments and number of employees. However, the manufacture of office,

accounting, and computing machinery (ISIC 3000) is, on average, the largest industry in terms of firm size.

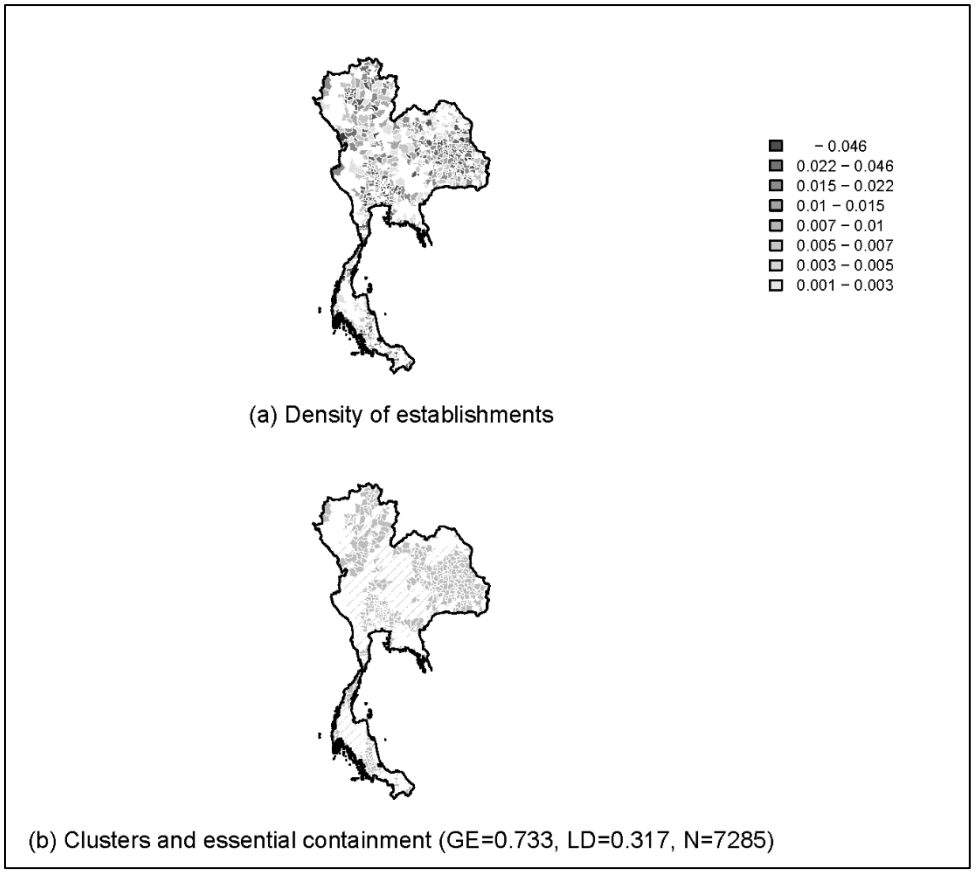
Table 3: Significant Industries in Thailand

	Name of Industry	Number of Establishments	Name of Industry	Number of Employees	Name of Industry	Number of Employees per Establishment
1	Wearing apparel (except fur)	5,475	Wearing apparel (except fur)	311,931	Office, accounting, and computing machinery	661
2	Weaving of textile	4,225	Electronic valves and tubes and other electronic components	230,600	Electronic valves and tubes and other electronic components	521
3	Other wood products, cork, straw, and plaiting materials	3,242	Plastic products	197,418	Optical instruments and photographic equipment	425
4	Structural metal products	2,963	Weaving of textile	169,404	Television and radio receivers and associated consumer goods	346
5	Other food products	2,890	Processing and preserving of fish and fish products	162,004	Bearings, gears, gearing and driving elements	341

Agglomeration of the wearing apparel industry in Thailand is relatively globally dispersed and locally sparse with a large value of GE (0.733) and a fairly low value of LD (0.317) (Figure 3.3-2). Since manufacturing of wearing apparel is a labour-intensive industry that requires mostly unskilled workers, it is relatively easy to set up such a unit in any part of the country. At the very first stage of industrial development, wearing apparel manufacturers were established in Bangkok and the metropolitan area due to proximity to both the customers and suitable workers. Later, when labour

scarcity occurred as there were lots of firms in the region, newcomers and incumbents who would like to expand their operation located their factories in other regions. Distance is not a serious constraint since the bulk transportation of wearing apparel products and their raw materials is easy and cheap. This results in a globally dispersed and locally sparse pattern of agglomeration by the wearing apparel industry in Thailand. According to the 2007 industrial census data, 94 percent of the wearing apparel manufacturers in Thailand are small and medium-sized enterprises spread throughout the country. On the other hand, the larger manufacturers were located in Bangkok and the metropolitan area and in the provinces with a relatively large number of workers.

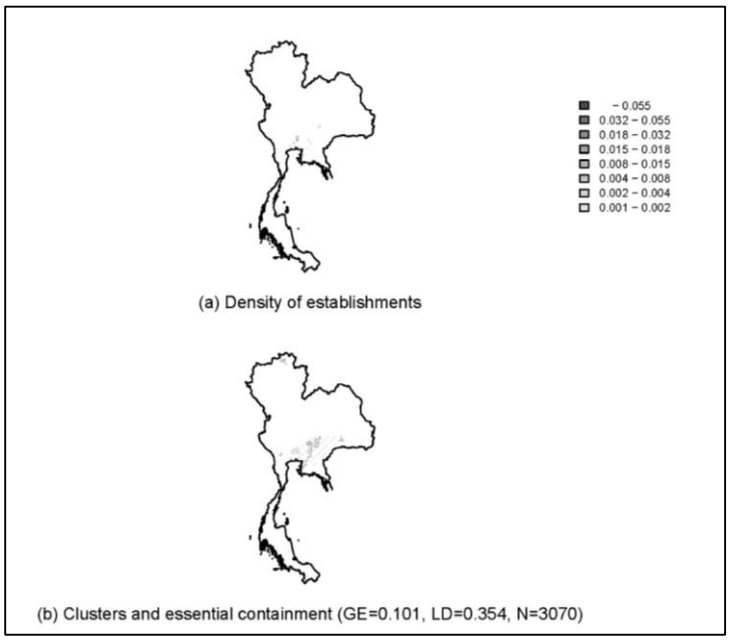
Figure 3.3-2: Manufacture of Wearing Apparel, Except Fur (1810): Thailand



Note : GE = global extent, LD = local density.

Regarding the manufacture of office, accounting, and computing machinery, its agglomeration pattern is globally contained and locally sparse with a markedly low value of GE (0.101) and a fairly low value of LD (0.354) (Figure 3.3-3). The main players in this industry are two big multinational companies (MNCs) producing hard disk drives. One is located in PhraNakhon Si Ayutthaya and the other is 185 kilometres away in Nakhon Ratchasima. Although these two companies can produce many parts and components themselves, they still source some components from suppliers in the supply chain that meet the required quality, cost, and delivery performance standard for this industry. As a result, unlike the wearing apparel industry, the distance among firms matters. However, it is quite a common practice in this business that suppliers are likely to sell parts and components to both MNCs. Thus, these suppliers have located themselves in close proximity to both MNCs, e.g. in PhraNakhon Si Ayutthaya, Nakhon Ratchasima, Prachin Buri, and Pathum Thani. As a large number of workers are required, firms manufacturing office, accounting, and computing machinery are rarely located in the same area (except in some industrial estates) to avoid the labour shortage.

Figure 3.3-3: Manufacture of Office, Accounting, and Computing Machinery (3000): Thailand



Note : GE = global extent, LD = local density.

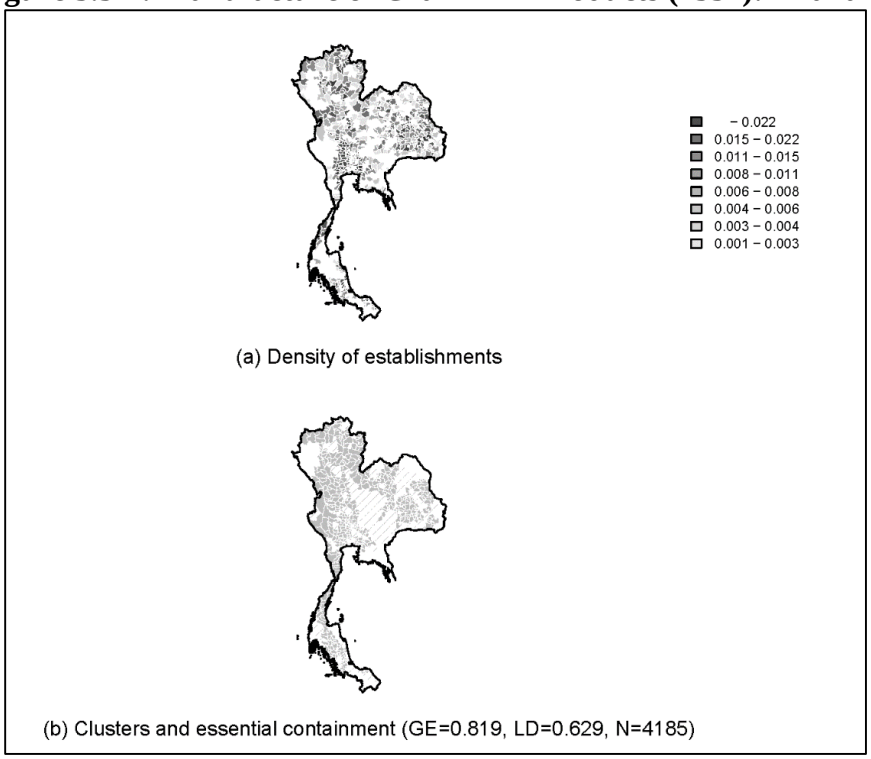
3.3.2 Four Location Patterns of Industrial Agglomerations

(1) Globally Dispersed and Locally Dense Patterns

There are two industries in Thailand that markedly exhibit a globally dispersed and locally dense pattern of agglomeration, as they have a noticeably high value of both GE and LD. These include manufacturing of grain mill products (ISIC 1531) and manufacturing of macaroni, noodles, couscous, and similar farinaceous products (ISIC 1544). The GE and LD of the first are 0.819 and 0.629, while the latter are 0.814 and 0.637, respectively (Figure 3.3-4 and Figure 3.3-5).

Regarded as 'the rice bowl of Asia', Thailand has a vast and fertile flood plain in many provinces throughout the country suitable for rice growing. After harvesting, rice is milled and further processed to yield a variety of products, e.g. farinaceous products. The technology and machinery for rice milling and processing are generally not complicated. In addition, milled rice and farinaceous products have long been served in many Thai dishes regardless of any regional variation. As a result, the two industries are ubiquitous and exhibit globally dispersed and locally dense patterns of industrial agglomeration.

Figure 3.3-4: Manufacture of Grain Mill Products (1531): Thailand



Note : GE = global extent, LD = local density.

Figure 3.3-5: Manufacture of Macaroni, Noodles, Couscous, and Similar Farinaceous Products (1544): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.814, LD=0.637, N=2851)

Note : GE = global extent, LD = local density.

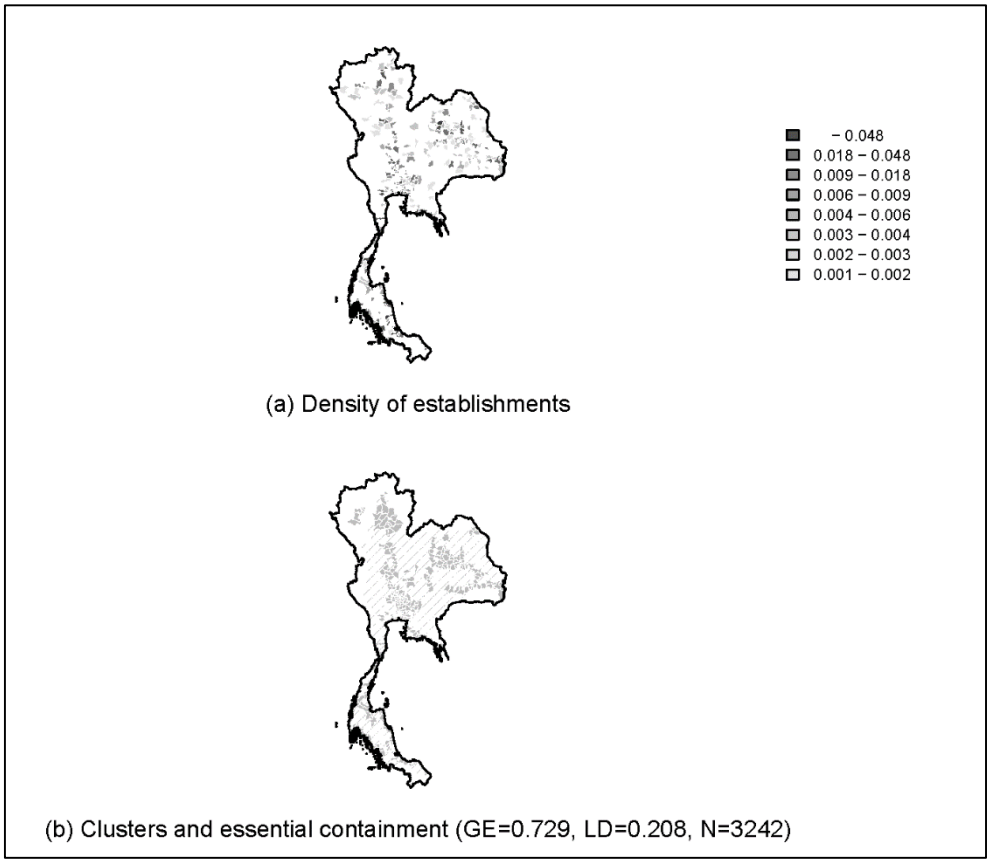
(2) Globally Dispersed and Locally Sparse Patterns

There are six industries in Thailand that exhibit a relatively globally dispersed and locally sparse pattern of agglomeration as they have noticeably high GE values but fairly low LD values. These include processing and preserving of fish and fish products (ISIC 1512), manufacturing of wine (ISIC 1552), manufacturing of glass and glass products (ISIC 2610), manufacturing of non-structural non-refractory ceramic ware (ISIC 2691), manufacturing of furniture (ISIC 3610), and manufacturing of jewellery and related articles (ISIC 3691). The GE and LD of these industries range from 0.728 to 0.799 and from 0.208 to 0.255, respectively (Figure 3.3-6 to Figure 3.3-11).

Although these industries have different characteristics, they share at least two that may describe the same patterns of agglomeration. Firstly, like the manufacturing of grain mill products and farinaceous products, consumers of the six industries are

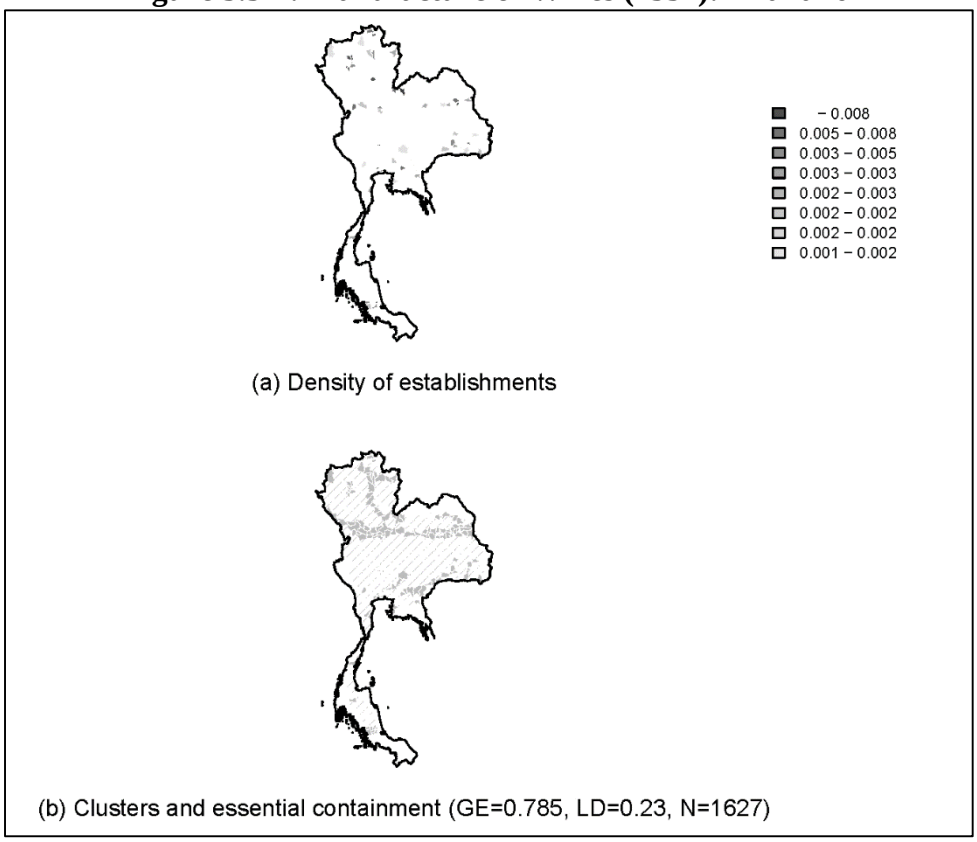
ubiquitous in the country. This characteristic can well explain why the manufacturers spread throughout the country. Secondly, the production processes of these industries require workers with some specific expertise, craftsmanship, or specialty. The manufacture of ceramic ware, furniture, and jewellery is typically difficult for newcomers to recruit workers if there are many other firms already operating in the same neighborhood. Thus, the clusters of these establishments are not located close to each other. This is also the case with fish product and wine-making establishments. To survive and thrive in these sectors, a location near good-quality raw materials is not the only key success factor. In fact, firms also have to develop their own unique recipes.

Figure 3.3-6: Processing and Preserving of Fish and Fish Products (1512): Thailand



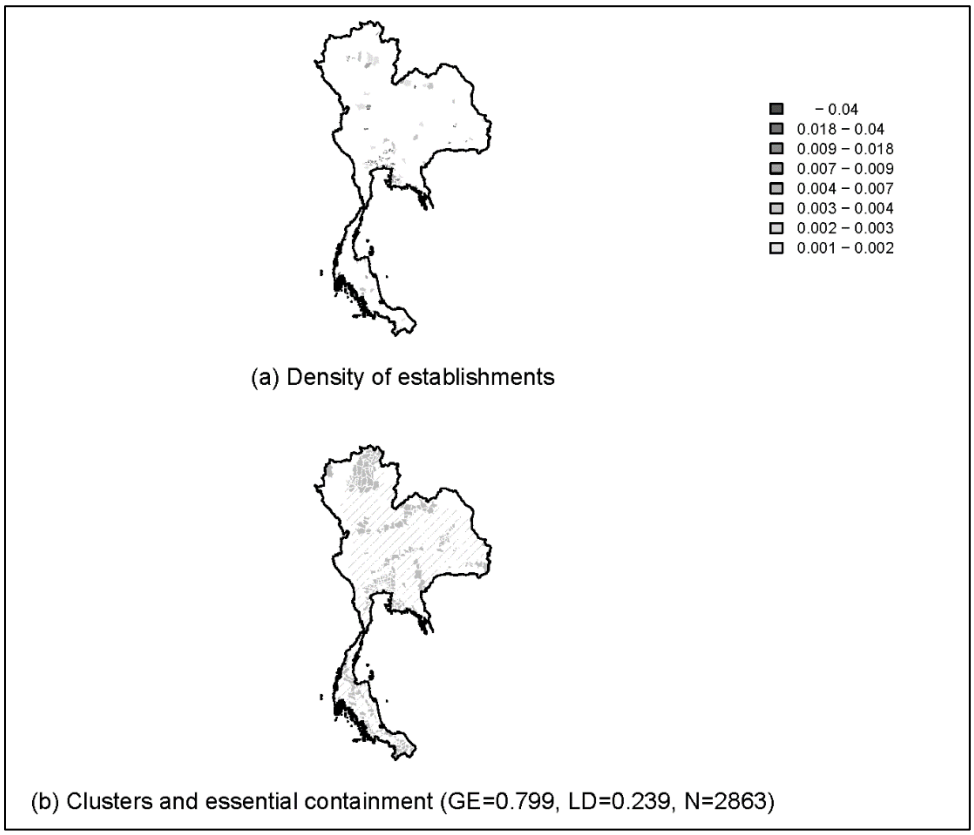
Note : GE = global extent, LD = local density.

Figure 3.3-7: Manufacture of Wines (1552): Thailand



Note : GE = global extent, LD = local density.

Figure 3.3-8: Manufacture of Glass and Glass Products (2610): Thailand



Note : GE = global extent, LD = local density

Figure 3.3-9: Manufacture of Non-Structural Non-Refractory Ceramic Ware (2691): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.735, LD=0.211, N=3448)

Note : GE = global extent, LD = local density

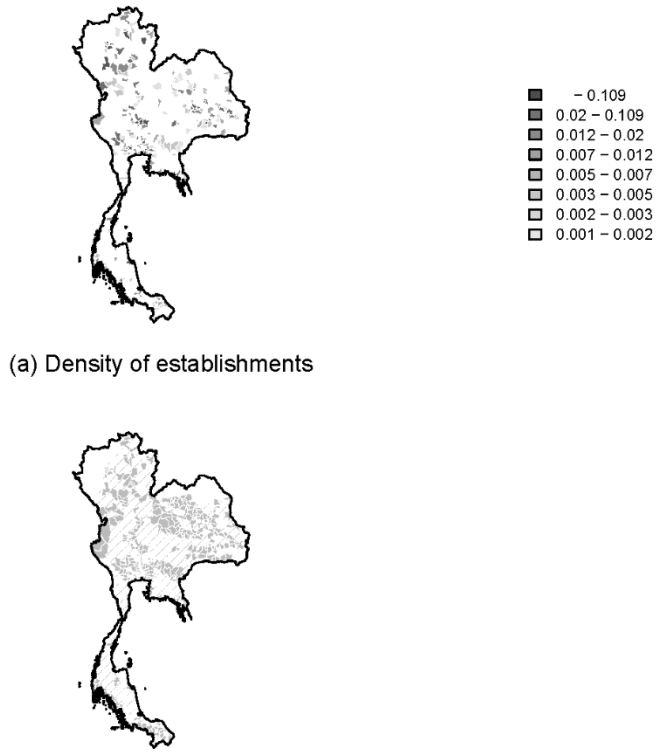
Figure 3.3-10: Manufacture of Furniture (3610): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.728, LD=0.255, N=6454)

Note : GE = global extent, LD = local density

Figure 3.3-11: Manufacture of Jewelry and Related Articles (3691): Thailand



(a) Density of establishments

(b) Clusters and essential containment (GE=0.754, LD=0.216, N=5051)

Note : GE = global extent, LD = local density

(3) Globally Confined and Locally Dense Patterns

There are four industries in Thailand that exhibit a globally confined and locally dense pattern of agglomeration as they have a remarkably low value of GE but noticeably high value of LD. These include the manufacturers of basic iron and steel (ISIC 2710), the manufacturers of lifting and handling equipment (ISIC 2915), the manufacturers of electric lamps (ISIC 3150), and the manufacturers of industrial process control equipment (ISIC 3313). The GE and LD of these industries range from 0.007 to 0.151 and from 0.743 to 0.865, respectively (Figure 3.3-12 to 3.3.-15).

There are two plausible explanations why these four industries exhibit globally confined and locally dense patterns of agglomeration: economies of scale and close proximity to suppliers.

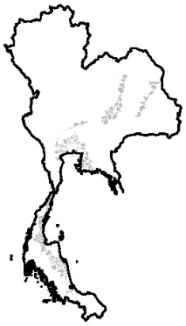
Economies of scale may be a crucial and plausible factor why the manufacture of basic iron and steel is densely located only in Samut Prakan, Rayong, Chonburi, and

Prachuap Khiri Khan, while the manufacture of electric lamps predominately exists in Bangkok and the metropolitan area. Competitiveness is positively related to the scale of production as well as the cost of essential inputs. To ensure the economies of scale, firms need to produce and sell beyond the breakeven scale of operation to cover all of the fixed costs.

The proximity to suppliers is a likely reason for the agglomeration of lifting and handling equipment manufacturers and industrial process control equipment manufacturers. The production of these products requires a great number of parts and components supplied by nearby suppliers. As a result, a number of firms producing industrial process control equipment are agglomerated in Bangkok, Samut Prakan, and Pathum Thani, whereas the manufacturers of lifting and handling equipment are located in Bangkok, Samut Prakan, PhraNakhon Si Ayutthaya, Rayong, Chonburi, and Chachoengsao.

Figure 3.3-12: Manufacture of Basic Iron and Steel (2710): Thailand

(a) Density of establishments



(b) Clusters and essential containment (GE=0.041, LD=0.777, N=3132)

Note : GE = global extent, LD = local density

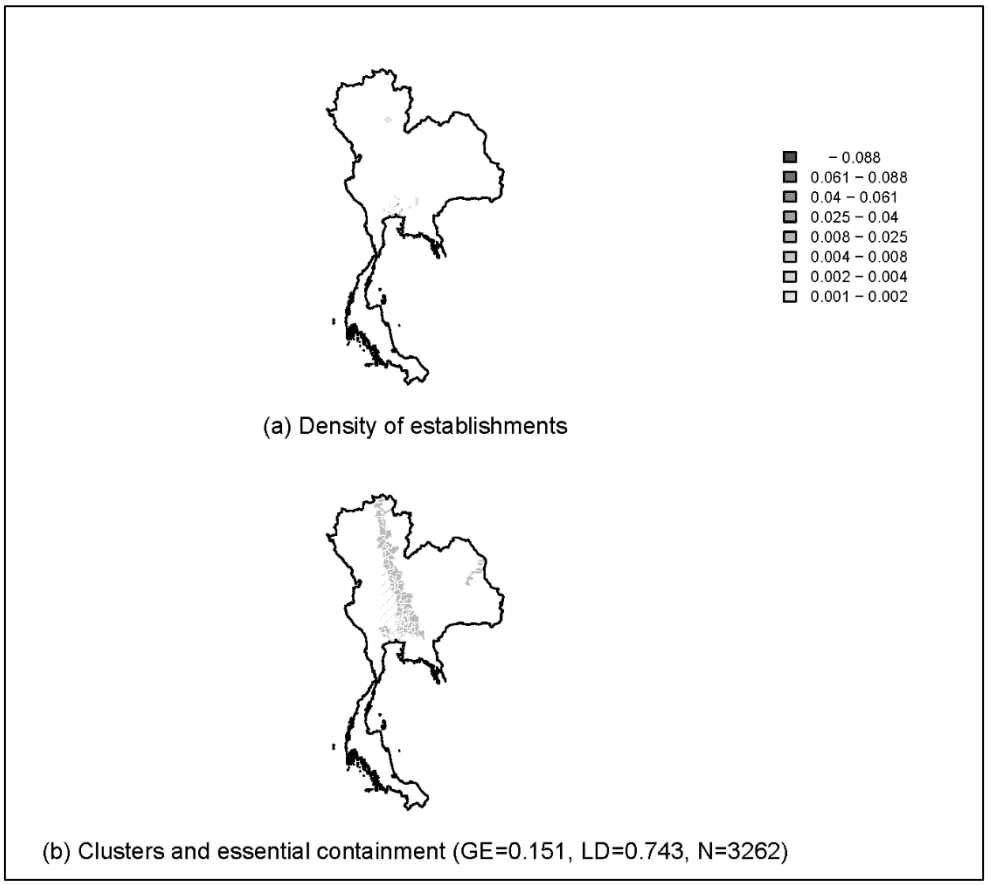
Figure 3.3-13: Manufacture of Lifting and Handling Equipment (2915): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.024, LD=0.865, N=3000)

Note : GE = global extent, LD = local density

Figure 3.3-14: Manufacture of Electric Lamps (3150): Thailand



Note : GE = global extent, LD = local density

Figure 3.3-15: Manufacture of Industrial Process Control Equipment (3313): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.007, LD=0.758, N=3325)

Note : GE = global extent, LD = local density

(4) Globally Confined and Locally Sparse Patterns

There are five industries in Thailand that exhibit a globally confined and locally sparse pattern of agglomeration, as they have an extremely low value for both GE and LD. These include tanning and dressing of leather (ISIC 1911); reproduction of recorded media (ISIC 2230); manufacturing of steam generators except central heating hot water boilers (ISIC 2813); manufacturing of instruments and appliances for measuring, checking, testing, navigating, and other purposes except industrial process control equipment (ISIC 3312); and manufacturing of aircraft and spacecraft (ISIC 3530). The GE and LD of these industries range from 0.094 to 0.127 and from 0.073 to 0.123, respectively (Figures 3.3-16 to 3.3-20).

The globally confined and locally sparse patterns of these five industries are consistent with the fact that there are only a few manufacturers in these industries in Thailand. Although there are not many domestic competitors, they are struggling to compete against imported products. Close proximity to the customers is thus a key factor in determining a plant's location. In addition, to increase competitiveness, hundreds of leather tanning and dressing firms have organized themselves collectively as an association to develop their own industrial zones.

While there are some tanning and dressing of leather manufacturers in Bangkok, Rayong, and Chonburi, the main leather tanning and dressing clusters are mostly located in Samut Prakan. The media reproduction firms are located in Bangkok, Nakhon Pathom, and Pathum Thani. The key players in the manufacture of steam generators are located in Ratchaburi and Samut Prakan. The manufacturers of instruments and appliances for measuring, checking, testing, navigating, and other purposes are located in Bangkok, Pathum Thani, and Chachoengsao. The manufacturing activity for aircraft and spacecraft can be seen in Pathum Thani, Chonburi, and Rayong.

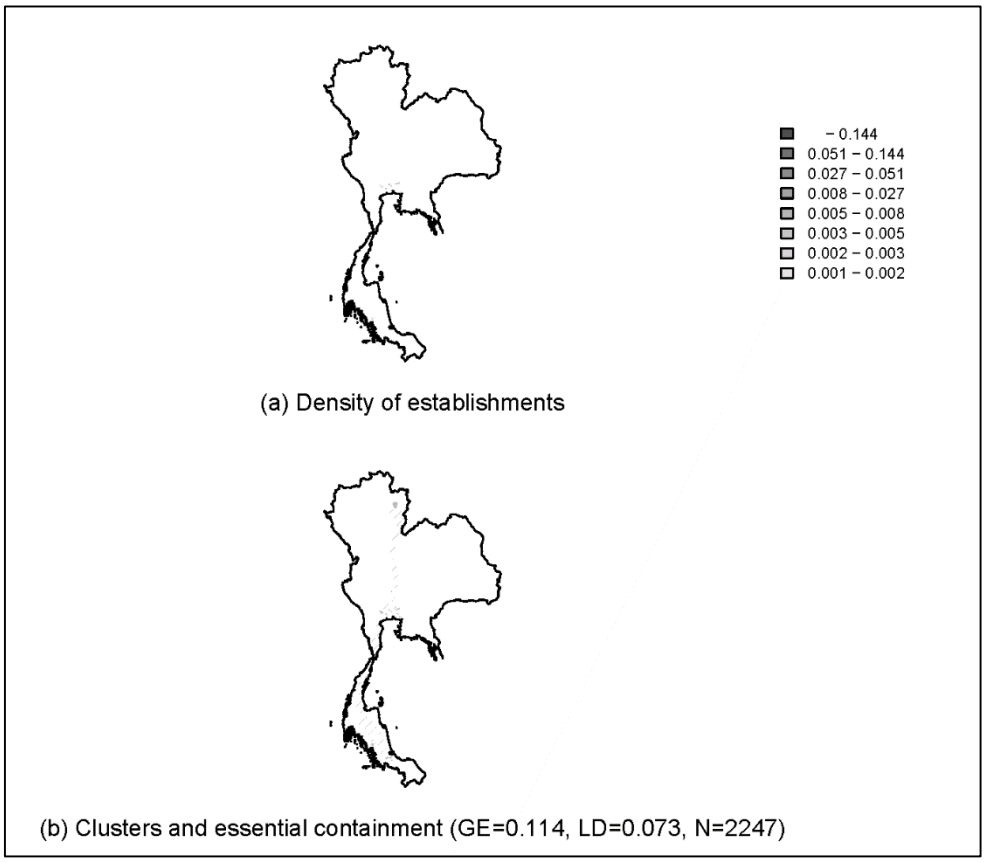
Figure 3.3-16: Tanning and Dressing of Leather (1911): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.127, LD=0.1, N=2034)

Note : GE = global extent, LD = local density

Figure 3.3-17: Reproduction of Recorded Media (2230): Thailand



Note : GE = global extent, LD = local density

Figure 3.3-18: Manufacture of Steam Generators, Except Central Heating Hot Water Boilers (2813): Thailand

(a) Density of establishments

(b) Clusters and essential containment (GE=0.094, LD=0.083, N=2839)

Note : GE = global extent, LD = local density

Figure 3.3-19: Manufacture of Instruments and Appliances for Measuring, Checking, Testing, Navigating, and Other Purposes, Except Industrial Process Control Equipment (3312): Thailand

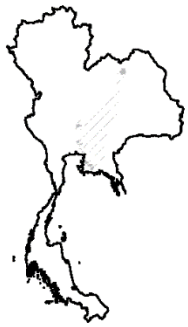
(a) Density of establishments

(b) Clusters and essential containment (GE=0.104, LD=0.123, N=3342)

Note : GE = global extent, LD = local density

Figure 3.3-20: Manufacture of Aircraft and Spacecraft (3530): Thailand

(a) Density of establishments



(b) Clusters and essential containment (GE=0.098, LD=0.103, N=3536)

Note : GE = global extent, LD = local density

4. Conclusion

We applied the Mori and Smith (2013) method to identify major manufacturing activities and detect manufacturing clusters in Cambodia, Lao PDR, and Thailand. The establishment-level official statistics for the three countries enabled us to categorize the agglomeration of manufacturing establishments into four spatial patterns at either the detailed industry or product level.

Descriptive statistics show that natural resource processing industries such as grain mill production are recognized as significant industries in terms of the number of establishments in the three countries. This finding reflects the dominant role played by local establishments in shaping the industries that use locally procurable raw

materials as the main inputs. In terms of the number of establishments, labour-intensive export-oriented industries such as wearing apparel, textiles, and footwear are significant in Cambodia and Thailand (to a lesser extent in Lao PDR). The average establishment size, i.e. the number of employees per establishment, reflects the difference in the stage of industrial development between Thailand and its neighboring countries. The larger establishments in Thailand produce electronic machineries, while those in Cambodia and Lao PDR are mainly involved in labour-intensive or natural resource processing industries. Compared with Cambodia and Lao PDR, Thailand has achieved diversification of manufacturing activities into more technically sophisticated industries by attracting foreign direct investment.

The Mori and Smith (2014) method clarifies the widely shared recognition of rice farming and related industries as fundamental productive activities in rural areas in the Mekong basin countries. The grain and rice milling industry exhibits a globally dispersed and locally dense pattern in all three countries, which reflects the fact that rice and other grains are cultivated and consumed ubiquitously in these countries. A globally dispersed and locally sparse location pattern is observed for some industries such as dairy products (Cambodia); frozen meat of mammals (Lao PDR); and fish products, wine, glass products, ceramic ware, and so on (Thailand). Considering the characteristics of these industries, such a location pattern can be observed when the consumers of these products are spread across economically active areas, while the production needs productive factors that are not available ubiquitously. Such factors include raw materials and workers' skills that are only available locally.

There are many industries that exhibit a globally confined and locally dense pattern in Cambodia and Lao PDR. Industries that contain only one establishment automatically illustrate this location pattern. The limited diversity in manufacturing activities in these less industrialized economies is reflected in the location pattern of manufacturing establishments, whereas the case of Thailand attributes economies of scale in production as one of the reasons for exhibiting this location pattern. Nevertheless, a case like ceramic products in Lao PDR should be further investigated from the viewpoint of both economic and non-economic factors (Mori and Smith, 2014) as this location pattern is governed by historical circumstances.

There are various industries that exhibit a globally confined and locally sparse pattern: in Cambodia, pulp, paper, and paperboard; in Lao PDR, other knitted or crocheted fabrics; and in Thailand, leather; recorded media; steam generators; instruments and appliances for measuring, checking, testing, and other purposes; and aircraft and spacecraft. One of the reasons for this location pattern by some industries may be a limited number of industrial clusters that constitute a relatively narrow essential containment. Examples of this pattern include the paperboard industry in Preah Sihanouk province and Phnom Penh, Cambodia, and the modern fabric-related industry in Vientiane, Lao PDR.

We have described several limitations to our study. The first is the lack of analysis on the collocation pattern of different industries. Agglomeration of an industry can attract other industries through agglomeration externalities. This limitation makes it difficult for a policy maker to predict which clusters will induce the development of what new industries. The second is that our study calculates the distance between two areas based on the direct line between the centroids of each region, whereas Mori and Smith (2014) recommend using network distance. Our streamlined procedure for calculating the inter-area distance may identify different regions as a part of clusters from the regions detected by the Mori and Smith (2014) approach. The third is the difference among the three countries in the industrial classification system and the year when each country conducted the survey. These differences make it difficult to achieve a rigorous international comparison. The fourth is the usage of cross-sectional data. Panel data are needed to observe whether agglomeration is associated with industrial growth by the existing industries or the generation of new industries.

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