Clustering and Industrial Development: Evidence from Thailand

by

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Abstract

This research aims at answering three main research questions: (1) what determines spatial clustering of manufacturing establishments? (2) What are the effects of industrial clustering on manufacturing establishments' performance? And (3) what are the mechanisms through which industrial clustering may contribute to the improvement of manufacturing establishments' performance? The analysis in this research is based on two methodologies; one is regression analysis using Thailand's industrial census data, the other is a case-study analysis of the silk-weaving industry in Pak Thong Chai (PTC) District, Nakhon Rachisima Province of Thailand. The main research findings are as follows.

First, the Bangkok Metropolitan Region (BMR) is defined as the only established industrial cluster in Thailand, whereas there exist emerging clusters which are the provinces that are moving toward the formation of industrial clusters. Thus, the location analysis examines both establishments' decision to be located in the BMR (as industrial clusters) and establishments' decision to be located in emerging clusters. Manufacturing establishments that decide to be located in the BMR are generally large and skills-intensive establishments. The factors that make the BMR attractive for manufacturing establishments include a large pool of labor, availability of skilled workers, well-developed infrastructure, and its agglomeration economies. These factors can be viewed as the determinants of the existence of the industrial cluster. The factors that affect establishments' decision to be located in emerging clusters vary across industries; and these factors can be viewed as the determinants of the formation of industrial clusters. In the motor vehicle industry, important factors are a large pool of skilled workers and well-developed infrastructure. In the food products and beverages industry, the

share of resource-based sector in the gross provincial product (GPP) is an important factor. And in the textile industry, textile establishments are located in emerging clusters in order to utilize unskilled and cheap labor.

Second, by applying the two-stage least square regression, it is found that the *same-sector* agglomeration (localization economies) help improve establishments' labor productivity, while the *different-sector* agglomeration (urbanization economies) harm it. However, externalities generated from the same-sector agglomeration are positive only for spatial agglomerations of 2-digit industries, but negative for 3-digit and 4-digit agglomerations. This indicates that spatial clustering of broad-range and complementary activities is conducive for productivity improvement, while spatial clustering of narrow-range activities is not helpful for productivity improvement.

Finally, the case study of the PTC silk-weaving industry reveals that vertical inter-firm linkages between the buyer and subcontractors that are co-located in the industrial cluster (PTC) facilitate regular face-to-face interactions, knowledge transfer, and technological upgrading of subcontractors. The absence of such linkages generates furious competition and rival relations among silk-weaving establishments, and consequently reduces their performance.

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Chapter 1

Introduction

1.1 Statement of the problem

Industrial clustering has attracted much attention from researchers for many decades. As a real-world phenomenon, it has been observed that geographical agglomeration of industries has taken place in every part of the world and has occurred at various geographical levels – global, national, and regional (Brakman et al. 2004). Many theoretical and empirical works have been trying to explain why industries are geographically agglomerated or what cause industries to agglomerate spatially.[1] At the same time, instead of examining the causes of agglomeration, development literature has focused more on the effects of industrial clustering. Several studies try to address the question of whether geographical agglomeration of industries leads to a better performance of firms, regions, and nations.[2] Some researchers have gone even further and investigated mechanisms through which industrial clustering may help improve the performance of firms, regions and nations. They ask how and under what conditions industrial clustering leads to positive outcomes.[3]

Most studies on the causes of industrial agglomeration primarily examine the determinants of agglomeration. They generally attempt to find relevant characteristics of

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[1] For theoretical work on the causes of industrial agglomeration, see, for example, Krugman (1990a, 1990b, 1993) and Vanables (1996). For empirical work, see, among others, Ellison and Glaeser (1997), Kim (1995), Rosenthal and Strange (2001), Cohen and Paul (2005), and Ellison et al. (2007).

[2] For studies about the effects of agglomeration on the performance of regions and industries, see, among others, Segal (1976), Nakamura (1985), Glaeser et al. (1992), and Ciccone and Hall (1996). For studies about the effects of agglomeration on firm performance (e.g., productivity, employment, and start-up), see, for example, Rigby and Essletzbichler (2002), Lall et al. (2004), Becchetti et al. (2007), Baldwin et al. 2008), and Cainelli (2008).

[3] See, for example, Kennedy (1999), Knorringa (1999), Nadvi (1999), and Rabellotti (1999).

firms, industries, or regions which affect the overall level of agglomeration. The analytical practice which is usually taken in this body of literature is to measure the degree of industrial (or regional) agglomeration (usually by using well-known indexes such as Gini coefficient, Herfindahl index, and Ellison-Glaeser index), and then establish the relationship between the degree of agglomeration and characteristics of firm, industries, or regions (see Ellison and Glaeser 1997; Kim 1995; Rosenthal and Strange 2001; Traistaru et al. 2002; Cohen and Paul 2005; Vogiatzoglou 2006; Ellison et al. 2007).

The studies on the effects of industrial clustering mainly examine the relationship between clustering and performance of firms (regions or industries). Most of them attempt to establish whether and how agglomeration economies contribute to the improvement in economic performance of firms (regions or industries) such as productivity growth (Ciccone and Hall 1996; Rigby and Essletzbichler 2002; Baldwin et al. 2008), employment growth (Glaeser et al. 1992; Henderson et al. 1995), wage premium or wage growth (Glaeser and Mare 2001; Glaeser and Resseger 2009), innovation (Pane 2004), and start-up activities (Rosenthal and Strange 2003). Until recently, there have been many empirical studies which apply a regression analysis to test whether industrial clustering is significant for economic performance.[4] At the same time, there have been an increasing number of studies which rely on a case study approach to examine the mechanisms through which industrial clustering may contribute to the improvement of economic performance.[5]

Though rich in number and evidence on the causes and effects of industrial

[4] See, for example, Sveikauskas (1975), Ciccone and Hall (1996), Capello (1999), Ciccone (2002), Rigby and Essletzbichler (2002), Henderson (2003), Madsen et al. (2003), Cingano and Schivardi (2004), Koo (2005), Liu et al. (2005), Baldwin et al. (2008), Cainelli (2008), and Brown and Rigby (2009).
[5] See, for example, Saxenian (1991); Scott (1992); Gray et al. (1996); Kennedy (1999); Knorringa (1999); Nadvi (1999); Rabellotti (1999); Schmitz and Nadvi (1999), Saxenian and Hsu (2001), and Niosi and Zhegu (2005).

clustering, there are still some controversial issues and gaps in the body of literature. First, there has been an on-going debate over the issue of what kind of clustering is better for firm or regional performance. On one hand, some scholars (e.g. Nakamura 1985; Lall et al. 2004; Martin et al. 2008) argue that the geographical agglomeration of firms in the same industry (localization economies) is more relevant to improving the performance of firms and regions. On the other hand, other scholars (e.g. Jacobs 1969; Sveikauskas 1975; Tabuchi 1986; Glaeser et al. 1992) believe that the geographical agglomeration of firms from various industries (urbanization economies) is more important for firm and regional development. Evidence seems to vary with respect to time, sector, and country chosen for analysis.

Second, despite a number of studies examining the effects of industrial clustering, previous studies still do not provide sufficient explanation on the effects of clustering with respect to spatial and sectoral scopes. Specifically, there have been few studies thus far that attempt to elaborate spatial and sectoral extents to which the effects of clustering may take place (notable studies include Rigby and Essletzbichler 2002; Mare and Timmins 2006; Baldwin et al. 2008; Martin et al. 2008).

Finally, the literature on industrial clustering (especially those relying on a case study approach) so far has focused more on the modern industrial clusters in urban areas (e.g., Saxenian 1991; Scott 1992; Gray et al. 1996; Saxenian and Hsu 2001; Niosi and Zhegu 2005). Less attention has been paid to industrial clusters taking place in rural areas (notable exceptions include Sandee 1998; Weijland 1999; Sato 2000; Sandee and Rietveld 2001). Therefore, while the relationship between clustering and economic performance of urban-based firms has been well established, more evidence on whether and how rural firms benefit from industrial clustering is still needed. In other words, it is still necessary to establish whether industrial clustering helps rural firms improve their economic performance.

In this study, I attempt to contribute some empirical evidence to the body of literature on industrial clustering, taking the case of Thai manufacturing industries for analysis. First, I investigate the relationship between industrial clustering and the manufacturing establishments' performance by taking into account both urbanization and localization economies. This is to contribute to the urbanization-versus-localization debate in the body of literature.

Second, I examine the effects of industrial clustering on manufacturing establishments' performance at various spatial and sectoral scopes of agglomeration. Specifically, I investigate whether the effects of industrial clustering vary across various spatial and sectoral scopes of agglomeration. By doing so, it is possible to identify the spatial and sectoral scope of agglomeration which is most likely to help manufacturing establishments improve their economic performance.

Finally, I take a case study of rural industrial cluster (see Section 1.6) to examine the effects of clustering on the economic performance of rural-based manufacturing establishments as well as to explore the mechanism through which clustering may help those establishments improve their performance. The aim is to contribute more evidence on the relationship between industrial clustering and the performance of rural-based establishments.

It is worth noting that in this research manufacturing *establishment* is taken as a unit of analysis, rather than manufacturing *firm*. Thus, all statements made for a unit of analysis refer to manufacturing establishment. Also, in this study, *manufacturing industry* is the main focus. This is due to both theoretical as well as practical reasons. First, as most previous studies on industrial clustering take the manufacturing industry (rather than the service industry) for analysis, this study follows this standard approach in order to produce results that can be easily compared with previous ones. Second, in Thailand, data on the manufacturing industry is more complete and accessible than data on the service industry, making it more suitable for the analysis.

1.2 Research question

The main research questions to be addressed in this study are: (1) what determines spatial clustering of manufacturing establishments? Why are establishments geographically and sectorally clustered? (2) What are the effects of industrial clustering on manufacturing establishments' performance? Are establishments better-off when they are geographically and sectorally clustered, compared to when they are not clustered?, and (3) what are the mechanisms through which industrial clustering may contribute to the improvement of manufacturing establishments' performance?

To answer these questions, this study aims to (1) find determinant factors which explain the geographical and sectoral clustering of manufacturing establishments; (2) find the relationship between industrial clustering and establishments' performance; and (3) find mechanisms through which industrial clustering may help manufacturing establishments improve their performance.

1.3 Scope of the research

The scope of this research covers three main issues as follows:

1. It examines geographical agglomeration of manufacturing industries in order to identify the industrial clusters in Thailand, and then searches for determinant factors at both firm and regional levels which explain the spatial clustering of establishments in each industry.

2. It establishes some relationship between industrial clustering and manufacturing

establishments' performance. Here, labor productivity is taken as the indicator for establishments' performance. This is in line with many previous studies.

3. It examines the mechanisms through which industrial clustering may help to improve the economic performance of manufacturing establishments (in terms of technological upgrading, increases in sales, employment, profits, and labor productivity).

1.4 Industrial clustering: the case of Thailand

Thailand can be considered an interesting case for studying industrial clustering for several reasons. First, Thailand's industrialization in the past decades has been associated with a concentration of industrial activities in and around Bangkok. As industrialization began in the 1960s and 1970s, the center of industrial investment (especially foreign investment and import- and export-oriented industries) was Bangkok and its vicinity provinces[6] (known as the Bangkok Metropolitan Region: BMR). As a result, by the end of the 1980s, the BMR, which accounted for about 1.5% of the country's area and 10% of its population, contained 78% of all manufacturing establishments, 66% of financial services, and 52% of other services (Rigg 1991, p.157). Given that geographical distribution of manufacturing establishments is very unequal, it is interesting to investigate why spatial agglomeration of manufacturing establishments has taken place and how industrial clusters have been formed.

Second, not only are manufacturing establishments geographically concentrated, there also exists some spatial unequal distribution of productivity and output among regions in Thailand. Manufacturing establishments in the BMR and some provinces along the eastern coast (e.g., Chachoengsao, Chon Buri, and Rayong), in general, have registered higher productivity and output compared to peripheral regions (Romijn 1987; Parnwell and

[6] Five vicinity provinces of Bangkok include Samut Prakarn, Pathum Thani, Nakhon Pathom, Nonthaburi, and Samut Sakhon. These provinces together are sometimes called Inner Ring area (Poapongsakorn 1995).

Khamanarong 1996). An important question to ask is whether or not the concentration of establishments with higher productivity and output has something to do with geographical agglomeration of establishments; specifically, does geographical agglomeration of manufacturing establishments explain productivity and output growth?

These questions have never been addressed in previous studies on industrial development in Thailand. Despite a number of studies that have emerged to explain geographical concentration of Thai manufacturing industries, they only provide a broad analysis of concentration at the industrial and regional levels.[7] There has been no particular study on establishments' location decision in the agglomeration area. Recently, many researchers have been interested in studying industrial clustering (Lecler 2002; Intarakumnerd 2005; Harryono 2006; Wonglimpiyarat 2006; Teoh et al. 2007; and Tsuji et al. 2008). However, most of these have focused primarily on examining the industrial cluster-related policies of governments rather than the causes and effects of clustering. Particularly, these studies have not sufficiently discussed the determinants of cluster formation, especially characteristics of establishments or regions that are relevant for the formation of industrial clusters (notable exception is Tsuji et al. 2008).

Thus, taking Thailand as a case study not only contributes to filling the gaps in the body of literature on industrial clustering, but also provides some specific policy implications which can be drawn from a particular case study.

1.5 Definition of industrial cluster

As the concept of industrial cluster is very broad and researchers who study the

[7] Those studies are World Bank (1983), Rachain (1989), Tamboonlertchai (1989), Bigs et al. (1990), Chalamwong (1992), Tambunlertchai (1993), Poapongsakorn (1995), Kittiprapas (1999)

phenomenon of industrial clustering use the term differently (Cortright 2006),[8] it is important to base the analysis on a widely accepted concept. In this study, I use the concept of industrial cluster in the same way as it is used by Schmitz and Nadvi (1999), who define industrial cluster simply as *the spatial and sectoral agglomeration of firms*. This concept is also consistent with Marshall's localized industrial district which refers to the agglomeration of related firms in a particular location (see Marshall 1890). In short, in this study, industrial clusters consist of two important dimensions. First, the *sectoral dimension* refers to the agglomeration of manufacturing establishments in the same sector or agglomeration of manufacturing establishments whose products can be grouped in particular way (e.g., based on 2-digit, 3-digit, or 4-digit classification). Second, the *spatial dimension* refers to a geographical unit or location with a certain geographical boundary such as district, city, province, state, or region.

1.6 Data and methodologies

The analysis in this research relies on both quantitative and qualitative methods.

1.6.1 Quantitative method

To examine the determinants of industrial clustering and the effects of industrial clustering on manufacturing establishments' labor productivity, the study relies on regression analysis explained as follows.

- To answer the first research question (*what determines spatial clustering of manufacturing establishments?*), two stages of data analysis are conducted. First, the study

[8] Industrial cluster can be defined as a large urban agglomeration consisting of diverse activities or as a specialized industrial area concentrating on a single or a few related industrial activities (see Cortright 2006 for a review of the concept).

identifies industrial clusters as well as emerging clusters (i.e., provinces that are moving toward the formation of industrial clusters), and then finds which establishments are located in industrial clusters and which are located in emerging clusters. (Methods for identifying industrial clusters are discussed in Chapter 4). Then, logistic regression procedures are applied to regress a dichotomous dependent variable[9] on explanatory variables. The explanatory variables are measured at both establishment and regional levels and are derived from theories and previous empirical research on firm location and industrial agglomeration discussed in Chapter 2. In short, logistic regression analysis aims to determine characteristics of manufacturing establishments and regions (as explanatory variables) that are significant to the location of establishments in industrial clusters and in emerging clusters.

- To answer the second research question (*what are the effects of industrial clustering on manufacturing establishments' performance?*), the multiple regression method is applied. Establishment's labor productivity is regressed on an industrial clustering variable (defined as the number of establishments in the same sector and same location) controlling for other establishment characteristics (e.g. capital investment, number of labor, establishment size, age, and foreign investment) as well as regional characteristics (e.g. regional industrial structure, regional industrial competition, and agglomeration at the regional level). (Theoretical discussions about explanatory variables are given in Chapters 2 and 5).

The data used for quantitative analysis are mainly derived from two industrial census data sets (1997 and 2007) provided by the National Statistical Office of Thailand (NSO). The 1997 and 2007 census data sets represent the population of manufacturing establishments of all sizes (see Appendix 1.1). These data sets provide important information on characteristics of Thai manufacturing establishments such as geographical location, years of establishment,

[9] Each manufacturing establishment in my data set has a particular characteristic: either *located in* an industrial cluster (an emerging cluster) or *not located in* an industrial cluster (an emerging cluster).

ownership structures, import and export, number of workers, costs of production, sales, and value-added.

The numbers of manufacturing establishments in 1997 and 2007 data sets are 32,489 and 73,931, respectively. Other data sources are used to complement the census data including national account data provided by the National Economic Social Development Board (NESDB) and labor force statistics provided by the Ministry of Labor (MOL).

1.6.2 Qualitative method

In order to answer the third research question (*what are the mechanisms through which industrial clustering may help manufacturing establishments improve their performance?*), I conducted a case-study analysis by selecting a case of an industrial cluster in which manufacturing establishments are considered out-performed, and then investigating how or under what conditions industrial clusters help establishments upgrade their technologies, knowledge, and skills and improve productivity. The selected case is a silk-weaving industry in the Pak Thong Chai (PTC) District of Nakhon Rachasima (NR) Province. There are two reasons why this case is selected. The first reason is that the PTC district is well-known in Thailand as the center for silk-fabric production. In fact, it is also recognized by NESDB as one of the top 20 potential clusters in Thailand (KISIA 2006). Moreover, having calculated the location quotient (*LQ*) for PTC's silk-weaving industry, it was found that PTC is about 7.1 times more specialized in the silk-weaving industry than the average of the whole kingdom. (Chapter 6 gives an explanation of how *LQ* for PTC's silk-weaving industry is derived). The second reason is that this case is a good case of a rural cottage industry upgrading to become a modern industry. Originally, silk-weaving in PTC was carried out seasonally by rural households as an off-farm activity mainly for household consumption or for small trade with their neighbors (Kasikosol 1998). Recently, however, it is regarded as the silk-fabric production centre of the country. Thus, it is interesting to examine on one hand how this modern industrial cluster has been developed from a cottage industry, and on the other hand how clustering helps rural silk establishments upgrade and develop. As already mentioned, less attention has been paid to rural-based traditional industrial clusters in the existing body of literature; therefore, the case study of PTC silk-weaving industry can provide more evidence on the mechanisms which are relevant for upgrading and improving performance of small establishments located in the rural industrial cluster.

In order to get data on the silk-weaving industry in PTC, I conducted in-depth interviews with key informants as identified in Table 1.1

Table 1.1: Key informants and dates that interviews were conducted

Key informant(s)	Number (persons)	Date/Period interviewed
1. Owners/managers of silk-weaving establishments at PTC District	53	August-September 2007
		August-September 2008
2. Personnel manager of Thai Silk Company (Jim Thompson: JT) and JT's technician at PTC district	2	September 11, 2007
		August 23, 2008
3. Marketing manager of Shinawatra Thai Silk Co.Ltd.	1	September 21, 2007
4. President of Thai Silk Association	1	April 19, 2007
5. President of Pak Thong Chai Silk Association	1	September 4, 2008
6. Government officials from		
6.1 PTC District Office of Community Development	2	August 15, 2007
6.2 Department of Industrial Promotion,	1	August 30, 2007
Nakhon Rachasima provincial office		
6.3 Thailand Textile Institute	2	September 24, 2007

Source: Author

Data from the in-depth interviews are analyzed in two ways. First, I apply a genealogical approach to examine the historical evolution of each establishment and investigate the processes of establishment development over time. The main focus of this analysis is on the formation and development of inter-firm interactions, formal and informal linkages, and knowledge spillovers in the cluster. Also, I examine how the pattern of inter-firm interactions affects the performance of each establishment. Second, I conduct cross-establishment comparisons to see how establishments differ from each other in terms of business performance.

1.7 Significance of the research

Taking Thailand's manufacturing industrial clustering as a case study to answer the three main research questions discussed above, this study can have both theoretical and empirical contributions. In terms of theoretical contribution, this study is expected to broaden the understanding of the relationship between industrial clustering and manufacturing establishments' economic performance as follows. First, as the studies on the effects of industrial clustering have not sufficiently captured spatial and sectoral scopes of agglomeration, this study is one of a few studies to identify the effects of agglomeration in various spatial and sectoral settings. Second, by separating industrial agglomeration effects into those associated with urbanization economies and those with localization economies, this study contributes to the on-going debate in the literature on the forms of agglomeration economies that influence the establishments' productivity improvement (i.e., localization or urbanization economies - which are more conducive for productivity improvement?).

In addition, this study also has some empirical contributions. First, as the studies about the causes and effects of industrial clustering in Thailand are still very rare, taking Thailand's industrial clustering as a case for investigation can add more empirical evidence on causes and effects of clustering to the body of literature. Second, since this study takes the case of rural industrial cluster (i.e., silk-weaving industry in PTC district) as a case study, it can contribute more evidence on the mechanisms through which clustering may help rural-based establishments improve their economic performance.

1.8 Structure of dissertation

This dissertation consists of seven chapters. Following the introductory chapter, Chapter 2 reviews the bodies of relevant literature on firm location and industrial agglomeration. The purpose of reviews is to draw some concepts, arguments, and hypotheses from theories and empirical studies. Drawing from the bodies of literature reviewed, a conceptual framework used in this study is presented.

Chapter 3 employs industrial census and other relevant data to examine the pattern of geographical distribution of Thai manufacturing industries over time. The purpose of this chapter is to present the evidence that geographic agglomeration of Thai manufacturing differs across industries and the agglomeration exhibits some changes over time.

Chapter 4 examines the location of manufacturing establishments. It identifies industrial clusters and emerging clusters, and then shows the locations in which spatial clustering of manufacturing establishments takes place. In this chapter, the logistic regression method is applied to analyze the determinant factors which explain establishments' decision to be located in industrial clusters and their decision to be located in emerging clusters. It addresses the following research question: *what determines spatial clustering of manufacturing establishments?*

Chapter 5 applies the multiple regression method to test whether industrial clustering has positive and significant effects on establishment's labor productivity, controlling for establishment and regional characteristics. This chapter addresses the research question: *what are the effects of industrial clustering on manufacturing establishments' performance?*

Chapter 6 identifies the mechanisms through which industrial clusters may help upgrade and improve performance of rural-based small establishments. Utilizing data from in-depth interviews with key informants in the PTC silk-weaving industry, this chapter addresses the following research question: *what are the mechanisms through which industrial clustering may help manufacturing establishments improve their performance?*

Finally, Chapter 7 presents the conclusions of this research. It also provides some policy implications and future research issues.

Chapter 2

Causes and Effects of Agglomeration

2.1 Introduction

This chapter reviews the body of literature on industrial clustering in order to draw assumptions concerning the causes and effects of industrial clustering; particularly, assumptions related to the question as to how industrial clusters have emerged and how industrial clustering helps improve firms' performance. The chapter is structured as follows. Section 2.2 discusses the theories of and empirical evidence on industrial agglomeration which offer some hypotheses and ideas concerning why industries are spatially clustered. Section 2.3 reviews theoretical and empirical perspectives of industrial clustering and discusses how clustering affects firm performance. Finally, Section 2.4 discusses the conceptual framework used in this study.

2.2 Agglomeration of economic activities

Economists and economic geographers have long been interested in the spatial agglomeration of economic activities.[10] They have attempted to answer two important

[10] In fact, the original ideas about location of economic activities and effects of agglomeration can be traced as far back as the 19th century when the phenomenon and concept of agglomeration were first discussed intensively in Alfred Marshall (1920)'s writing about the organization of England's manufacturing industries which were concentrated in particular localities. Several decades after Marshall (1920) publication, spatial economic issues have been studied widely by economic geographers, while mainstream economists have completely ignored these issues in their economic modeling. However, after Krugman (1991) has successfully showed why and how spatial variables are relevant in economic models explaining industrial location and regional growth, the concept and phenomenon of agglomeration and agglomeration economies have become widely used and studied in various fields, such as urban and regional economics, economic geography, international economics, industrial economics, business economics, and development economics (Karlsson 2008; Cortright 2006).

questions: why economic activities are agglomerated in space, and how such agglomeration may result in development and growth? These are two main questions to be discussed in this and the following sections, respectively.

The agglomeration of industries can be considered a normal phenomenon taking place across time, space, and sectors. A century ago, geographers observed that US manufacturing industries were concentrated in a relatively small part of the Northeast and the eastern part of the Midwest, called the “manufacturing belt”, which was estimated to contain about 74% share of US manufacturing employment at the beginning of the twentieth century. Although during the first haft of the century, manufacturing industries developed rapidly in many parts of the country, such share was still as high as 64% by 1954 (Krugman 1991a, pp 11-14). When considering industrial activities taking place in space, it has been obvious that such activities are concentrated at both global and country levels. For instance, about 61.1% of world’s GDP is concentrated in European Union, United States, China, and Japan (IMF 2010). In China, as of 2005, 41.8% share of manufacturing output is concentrated in only four coastal provinces: Guangdong, Shandong, Jiangsu, and Zhejiang (Chen and Lu 2009, p.242).[11] Considering the global hard disk drive (HDD) industry as an example of sectoral agglomeration, it is evident that most final assembly of HDDs now takes place in South East Asia, with a 64.2% share of output value and a 44% share of employment (Brakman et al. 2004, p.11).

As the phenomenon of industrial clustering has always been observed, basic questions that have been asked are: why are industrial activities agglomerated in particular localities? Why are firms geographically clustered? And what determines the location of firms? Answering these questions leads us to understand how industrial clusters emerge.

[11] For details about industrial agglomeration in East Asian countries, see World Bank (2009) which collects essays on economic geography in East Asia.

2.2.1 Resource-based approach

Traditional analysis of firm location and co-location is the so-called ***resource-based approach*** which sees resource endowment of the region as a key determinant of agglomeration. Influenced by David Ricardo's comparative advantage framework, Ohlin (1933) suggests that, with different endowments in terms of natural resources, raw materials, infrastructure and production capital, and labor force, regions are provided with a different set of advantages as well as disadvantages. Consequently, costs of production differ across regions based on their specific resource endowments; and these influence firms' location decision.

The resource-based approach is one of the core principles in neo-classical trade theory which models industrial location based on the assumptions of perfect competition, homogenous products, and non-increasing returns to scale (Brulhart 1998). Location is determined exogenously, by the so-called *first nature* (i.e., regional endowments in labor, capital, and natural advantages) (Krugman 1993). The first nature plays an important role in determining whether economic activity will be dispersed or concentrated over space. For example, if only a few regions in the economy account for a relatively large endowment in labor, they will be specialized in labor intensive industry; consequently, the whole economy will exhibit concentration of labor intensive industry in these regions. Based on the comparative advantage framework, the resulting location pattern will be inter-industry specialization; that is, each industry is located in region(s) that fit their production requirement the most (Brulhart 1998).

Ellison and Glaeser (1997) has empirically tested the resource-based thesis and noted that agglomerations can arise not only from localized industry-specific spillovers, but also from natural cost advantage of firms. In their subsequent work, Ellison and Glaeser (1999) find that about 20% of observed geographic concentration in US manufacturing industries can be explained by natural advantages. However, using data on German regions, Roos (2005) finds that the influence of natural advantage on industry location is very small: the net influence is only about 7%.

A refined version of the resource-based approach argues for the importance of supply of skilled labor force and R&D resources as primary determinants of firms' location (Anderson et al. 1990). It suggests that regional endowments in skills and knowledge affect firms' development activities and constitute innovation stimuli that are necessary for firms to sustain their competitiveness.

2.2.2 Scale-based approach

The resource endowment thesis has been challenged by scholars (e.g., Lancaster 1980; Ethier 1982) who explain the location and agglomeration of firms in the context of internal and external economies of scale (Karlsson 2008). The location decision of firms largely depends on a dynamic interaction between internal economies of scale and external economies of market size. The production level of a firm cannot be explained by production function alone; it is also a function of industry-wide output. As output increases at the industrial level and industry as a whole enjoys increasing returns to scale, a firm's average costs of production tends to decrease in every increasing unit of production. Consequently, firms also enjoy increasing returns to scale (Brakman et al. 2001).

In fact, the size of the market allows firms to reach scale economies by making them realize the potential of division of labor and decomposition of production and specialization (Beckman 1958). When these take place at the industrial level, firms capture the potential by outsourcing production and take advantage of industry-wide external economies of scale.

Firms search for functional regions with a sufficiently large market potential to make it possible to produce at a profitable level, and functional regions in which many firms want to be located to develop a large market potential (Karlsson 2008).

A sharp contrast between the scale-based approach and the resource-based approach is quite obvious: while the former explains firm location and agglomeration on a demand-driven basis (i.e., customer market potential), the latter explains it on supply-driven basis (i.e., input market potential). According to Harris (1954), demand is high in areas where production is located as a result of the purchasing power of the workers making production at that location possible.

2.2.3 Weber's transportation cost minimization

What is lacking in both resource-based and scale-based analyses of firm location is the insight that the costs of transporting inputs and final products are a function of geographical distance. A rational firm, therefore, must select a location such that transport costs are minimized.

An original idea about the effect of transport costs on firm location decision can be found in Weber (1909). According to Weber (1909), in deciding the location of production, firms face the choice problem: where to locate production to minimize the sum of transport costs of input and output. Weber elaborated this problem by showing a simple model in which firms use two different inputs (say, input 1 and 2) to produce one output.[12] Each input is supplied from different location, and output is demanded by another location. Input and output markets are assumed to be pre-located, but the location of firms' production is not. The cost of transporting input 1 and input 2 to the production site is given by C_1 and C_2,

[12] Later, the model was extended to the case of multiple inputs and outputs (see Beckmann and Theisse 1986)

respectively, while the cost of delivering the output to the customer market is represented by C_{rm}, where subscripts *r* indicate firm's production location and *m* customer market place. For each location *r* that a firm selects, total transport cost (T_r) per unit of output can be calculated as $T_r = C_1 + C_2 + C_{rm}$. Thus, in deciding where to locate the production, firms must select the location that minimizes T_r.[13]

It is clear from Weber's idea that location of firms is influenced by agglomeration: the area where input suppliers and customers are agglomerated (i.e. large urban area) is the area where firms can optimally minimize total transport cost, and thus is the best location choice. This is especially true for differentiated and distance-sensitive products in which transport cost occupies a large share of firm's total cost. Firms that sell differentiated and distance-sensitive inputs will be motivated to locate their plants in the location with concentrated demand for these inputs, while firms that buy these inputs will also be attracted to the same location because it is where the transport cost of input can be optimally minimized. Obviously these two sides (i.e., input-buying firms and input-selling firms) reinforce each other and lead to a strong pattern of agglomeration (Henderson 1977).

2.2.4 New Economic Geography (NEG)

The main focus of NEG is on explaining the formation of a large variety of economic agglomeration (or concentration) in geographical space. It criticizes the theories of traditional trade and regional economics – which explain the location of economic activities based on factor price differentials – for their inability to show how agglomeration of economic activities takes place (Fujita 2007). In the NEG's framework, agglomeration of firms is

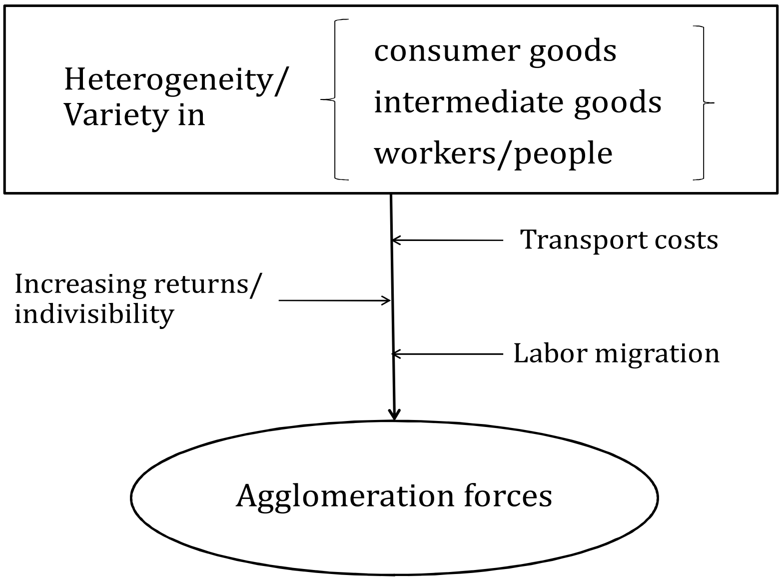
[13] Issard (1951) and Moses (1958) argue that firm's location problem should not be viewed solely as a function of transport cost, but also as a more general production problem. Firm's production choice can be made by considering relative prices of inputs together with relative costs of transportation. In reality, firm not only minimizes input and output delivery cost, but also production costs.

determined by the interaction of three factors: increasing returns, transport costs, and the role of demands (Krugman 1991a; Krugman 1991b; Fujita 2007).

In the core-periphery model (with two regions producing two kinds of goods: agricultural and manufactured), Krugman (1991a, 1991b) has shown that there are large differences in location and geographical distribution between agricultural activities whose production is subject to constant return to scale and intensive use of immobile land (i.e., agriculture) and manufacturing activities whose production is determined by increasing return to scale and modest use of land. According to him, the geographical distribution of agricultural activities will be *exogenously* determined by distribution of suitable land, while geographic distribution of manufacturing activities will be *endogenously* determined by scale of production, market demands, and transportation costs. To be precise, manufacturing firms tend to be set up in a limited number of locations where there is a sufficiently large number of pre-existing firms and a population that can generate large market demand. By locating in such places, firms can attain scale economies as well as keep transportation costs (i.e., costs of transporting input or final products to their markets) relatively minimal. When manufacturing location takes place in a particular area, it tends to attract more firms and labor, and consequently generate greater market demand. This process of industrial agglomeration tends to reinforce itself and can thus be considered a *circular causation* (Krugman 1991b; Fujita 2007).

Fujita (2007) shows how agglomeration forces are generated (see Figure 2.1). He proposes that when goods are sufficiently heterogeneous or can be differentiated from each other, their suppliers can be located in proximity to each other without bearing severe price competition, while consumers or users can enjoy the complementarity of such heterogeneous goods by being located closely to their suppliers. Key elements to generate agglomeration forces are increasing returns, transport costs, and migration of workers. Scale economies at firm level require that firms concentrate in the same location in order to benefit from greater market demands. By being located in such a way, firms can simultaneously attain increasing returns. Without scale economies, there will be no concentration of production: each household or small group of producers will produce all goods by themselves (Fujita 2007, p.10).

Figure 2.1: Generation of agglomeration forces



Source: Fujita (2007, p.11)

Transport costs also matters in keeping firms in a particular location or dispersing them to other locations. If transport costs are not significant (or zero), then there is no need for concentration; firms can locate their production anywhere as they can supply their products with very little or no transport costs from far away. However, when transport costs are extremely high, there will be no concentration of economic activities because it is too expensive to concentrate the production in one place and supply products from one location. In this situation, the economy will become an autarchy in which each location produces a small amount of all goods to supply only to their own market. Finally, when agglomeration of manufacturing firms takes place, it will naturally attract a number of workers whose location in the area can simultaneously generate greater demand and enhance home market effects (Fujita 2001).

As agglomeration proceeds further, however, congestion takes place, and congestion costs will eventually outweigh agglomeration benefits. Large agglomeration of firms and people causes an increase in wage and prices of land which consequently increase overall living and production costs. Industries (especially those whose main factors of production are labor and land) will tend to move to other locations where congestion costs are less severe (Fujita 2007; Combes et al. 2008). How fast dispersion process runs will depend, to a large extent, on transport costs: if transport costs are very low, then dispersion will be quick. However, the reduction of transport costs does not necessarily force all economic activities to disperse at the same rate. High-technology or knowledge-based sectors (e.g. high-tech R&D and software industries) are less sensitive to dispersion forces. These sectors need to be located in large urban areas in order to benefit more from knowledge spillovers. This explains why high-tech activities are usually concentrated in large cities such as New York, San Francisco, London, Tokyo, Seoul, and Shanghai (Fujita 2007).

2.3 Industrial clustering and performance of firms

If we believe that profit-maximizing behavior is a common characteristic of firms in general, then it is reasonable to ask the following questions: are firms better-off when they are geographically and sectorally clustered (i.e., when they are located in proximity to other firms in the same sector)?; are they able to improve their performance when they are located in the industrial cluster?; and if they are, then what are the mechanisms that help them do so? Precisely, what are mechanisms generated by industrial clusters that are significant for improving firms' performance?

The bodies of literature on industrial clusters and on economic geography have been trying to address these questions. They offer the explanation of how clustered firms improve their performance based on the so-called *Marshallian agglomeration economies* (or *Marshallian externalities*) which consist of labor market pooling, inputs sharing, and knowledge spillovers (Schmitz and Nadvi 1999; Duranton and Puga 2004; Rosenthal and Strange 2004).

2.3.1 Marshallian agglomeration economies/externalities

Alfred Marshall is credited as the first economist who generated the concept of agglomeration economies (Cortright 2006). He observed the phenomenon of spatial agglomeration of economic activities in England and identified the sources of better business performance when business units are spatially agglomerated, as compared to when they are spatially dispersed (Marshall 1920). According to him, when business units are sectorally and spatially agglomerated, positive externalities will be generated in the forms of availability of specialized input suppliers, labor market pooling, and spillovers of knowledge and information (Marshall 1920).

a. Labor market pooling

How does labor market pooling translate into the improved performance of firms? The advantage that arises when firms in the same industry are agglomerated in a particular location is the creation of a strong market for specialized and skilled labor. Sectoral and spatial agglomerations of firms reduce the costs that workers need to take to find their jobs. Workers, especially specialized workers, tend to be attracted to a place where they can easily find employment that fit their knowledge and skills in order to minimize the risk from a layoff and to create additional opportunities for advancement. When there exists a concentration of specialized and skilled labor, advantage accrues to firms: firms can acquire the workers they need at low (search) costs. This is clear from Marshall's (1920) original text which noted that:

> "Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market. The owner of an isolated factory, even if he has access to a plentiful supply of general labor, is often put to great shifts for want of some special skilled labor; and a skilled workman, when thrown out of employment in it, has no easy refuge (Marshall 1920, pp.225-226)".

In his seminal work, Krugman (1991) has elaborated Marshall's idea on labor market pooling. Assuming that firms' demands for labor are uncertain and not perfectly correlated, Krugman (1991) has formally shown that the efficiency gains will accrue to both firms and workers involved in the localized industry with a pooled labor market during *bad times* (e.g., economic or firm-specific shocks) and *good times* (e.g., excess demand for labor). By being located in the same place, firms experiencing good time with excess demand can possibly fulfill their demand due to the uncorrelated demand schedule of other firms experiencing bad time, and the pooled labor market will always keep workers available. This is not possible when firms are isolated because the fluctuation of one firm's labor demand cannot be compensated by that of another firm. At the same time, gains will accrue for workers in the form of constant labor demand; that is, one firm's bad time will be offset by another firm's good times, and the average rate of unemployment will correspondingly be lower (Krugman 1991, p. 40).

In clusters with pooled labor markets, the so-called hold-up problem, which arises when training occurs before a workers-firm pair is matched and in the absence of any ex-ante contract, can be reduced. The competition among firms for qualified labor ensures that workers will receive appropriate returns on their investment in the form of additional knowledge and skills (Rotemberg and Saloner 2000).

In a model of imperfect competition with differentiated products, competitive labor markets and endogenous decisions of labor qualification, Picard and Toulemonde (2004) argue that when workers decide to invest in human capital creation, they have no information about whether their knowledge and skills will be demanded by any firms. This makes them uncertain about the possibility of finding a good match with a firm that requires specific knowledge and skills. With the agglomeration of firms, however, the range of knowledge and skills demanded by firms expands; and consequently, the probability of matching between firms' demands and workers' knowledge and skills increases. This implies that, in the cluster, workers have more incentive to invest in human capital because the risk of mismatching can be reduced.[14]

Agglomeration and skills improvement can also reinforce each other. Toulemonde (2006) shows how this occurs. He argues that skilled workers (i.e., workers who invest in the acquisition of skills) earn more wages than unskilled workers. Firms are motivated to locate their production in regions with a large skilled workforce, not to utilize workers' skills but

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[14] This model also predicts endogenous agglomeration forces which happen when the supply of qualified tends to increase as the number of firms in the region increases. Simultaneously, pooled labor market in which the supply of qualified labor increases, wages tend to decreases; and consequently, more firms are attracted to the region (see Picard and Toulemonde 2004).

primarily to benefit from larger demands of high-wage skilled labor. At the same time, workers are eager to invest in the acquisition of skills when the number of firms demanding their skills increases. As more firms relocate their plants to a particular region, the number of skilled workers in that region increases.

Industrial agglomeration with a pooled labor market can also benefit firms and workers in two ways: first by protecting firms and workers from asymmetric shocks, and second by decreasing the labor mismatch problem. This is shown by Amend and Herbst (2008) in their human capital formation model based on the assumptions of imperfect completion and pooled labor market with heterogeneous workers and firms. The model specifically predicts that human capital will be augmented in the labor pooling market; as workers become more skilled, the distance in skill space across which workers can adjust will be extended. In the long-run, the workforce in a pooled labor market will not only be more productive but also more flexible in adapting to uncertainties and technological changes. The model also shows that, under the assumption of inter-regional labor immobility, a particular region can adapt to asymmetric shocks if it invests in workers' specific skills. Moreover, Amend and Herbst (2008)'s model also predicts firms' profits will increase in the pooled labor market due to low skill mismatch and efficient allocation of labor. In this situation, workers will gain more wages and be motivated to invest in accumulating human capital. The effects on productivity will be largest when: (1) there is a range of diverse industries producing under uncorrelated demand; and (2) similar firms can share a specific set of skills (Amend and Herbst 2008, p.25).

b. Availability of specialized input suppliers

Another advantage generated from spatial and sectoral agglomeration is that it increases availability and specialization of input suppliers. Marshall (1920) observes that when firms in the same industry are spatially concentrated, it creates a large demand for specialized inputs (e.g. machineries, tools, and business services). Large demand for inputs (or services) is very important to the development of specialized input suppliers (or business services) because when suppliers increase production volume, they can achieve economies of scale and production efficiency (Blair 1991; Krugman 1991). This can enable suppliers to invest in acquiring or producing expensive and sophisticated items, and thus lead to a specialization of input suppliers. It is noted in the Marshall's (1920) original text that:

> "…the economic use of expensive machinery can sometimes be attained in a very high degree in a district in which there is a large aggregate production of the same kind, even though no individual capital employed in the trade be very large. For subsidiary industries devoting themselves each to one small branch of the process of production, and working it for a great many of their neighbors, are able to keep in constant use machinery of the most highly specialized character, and to make it pay its expenses, though its original cost may have been high, and its rate of depreciation very rapid" (Marshall 1920, p.225).

There are some theoretical discussions concerning the relationship between industrial agglomeration and development of intermediate input suppliers. Krugman (1991) shows that intermediate input producers tend to locate their production in areas with industrial agglomeration in order to realize scale economies.[15] As a consequence of backward and forward linkages, the agglomeration of upstream suppliers and of downstream customers reinforces each other and increases the level of agglomeration. Increased demand for intermediate inputs motivates input suppliers to locate their production facilities closely to

[15] Krugman (1991) persists that that the agglomeration is still possible even in the case that the costs of transporting intermediate inputs are particularly low compared with those of transporting final goods. This view is different from Webber's idea that localized industries will emerge only if the costs of transporting intermediate inputs are more expensive than those of transporting final goods (see Krugman 1991).

their customers in order to realize scale economies as well as to minimize transport costs; on the other hand, the incentive for final goods producers to be located in places where input suppliers are agglomerated will be reinforced by the fact that intermediate inputs are cheaper there (Krugman 1991). This phenomenon is particularly possible for non-tradable (or distance-sensitive) input products, which are very expensive when delivered from distant locations. Thus, distance-sensitive transaction costs also play important roles in the location of intermediate input suppliers (Karlsson 2008).

In the empirical work, there is some evidence indicating that industrial cluster triggers local division of labor and vertical disintegration. Scott and Kwok (1988) examine location pattern and industrial organization of the printed circuits industry in Southern California and find that subcontracting and agglomeration are two highly associated phenomena. They suggest that the external transactions costs associated with vertical disintegration have definite impacts on patterns of industrial location, and tend in particular to encourage spatial agglomeration and polarization. In addition, Holmes (1999) investigates whether vertical disintegration is greater in areas where industries are localized. Using purchased-input intensity (i.e., purchased inputs as a percent of the value of output) as a measure of vertical disintegration, he finds that establishments located in areas where an industry is concentrated have a purchased-input intensity that is on average three percentage points higher than establishments located in areas where an industry is not concentrated. Moreover, two similar studies – one in China (Li and Lu 2008), the other one in Portugal (Guimaraes and Woodward 22008) – find strong evidence that industrial clustering would increase the degree of vertical disintegration, and consequently encourage the development of local intermediate input suppliers.

In summary, these empirical findings support Marshall’s (1920) argument that industrial clusters would result in the development of local input suppliers. In fact, Porter (1998) has also observed that agglomeration advantages accrue to both clients (core firms) and suppliers of inputs and services co-located in the cluster: suppliers gain from the nearby market for their output, while client firms gain from easy access to a range of services. The interaction between buyers and suppliers can trigger faster and more effective responses to technical problems or demand changes, benefiting all the firms in the cluster.

c. Knowledge spillovers

The last element of Marshallian externalities is information and knowledge spillovers which, according to Marshall (1920), can be acquired at no costs in the industrial cluster. He observed that when firms of the same industry are geographically clustered, knowledge and information from one firm will automatically spill over to other firms so that every firm in the cluster can easily learn from each other. According to him, such things as new knowledge, new ideas and innovation are short-lived and their creators cannot keep them for long because other firms that are located nearby have technological readiness to acquire those knowledge and ideas (i.e., as they operate in the same business, they have at least a basic knowledge about that business which allows them to easily imitate and copy new knowledge and ideas). Therefore, in the cluster, there are almost no secrets: knowledge and information flow easily as if they were moving through air. As Marshall (1920) notes:

> "When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighborhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one

> man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas. And presently subsidiary trades grow up in the neighborhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material" (Marshall 1920, p.225).

However, it may be possible to argue that if imitation and copying are so strong in the cluster, the probability of firms innovating would be reduced because the innovator runs the risk of being harmed by imitation and copying (Blair 1991). Arrow (1962) and Romer (1990), though conceding that knowledge spillovers within industry are keys to technological development and growth, maintain that lack of property rights to new ideas may slow down the development of innovation. If innovations can be copied and imitated too easily or are not appropriately compensated by the market, there will be no incentive to create innovations. Innovators need some form of monopolistic power over innovations that they create. Based on their ideas, therefore, technological development in industrial clusters will be faster if local industrial structure is to some extent monopolistic.

The ideas generated by Arrow (1962) and Romer (1990) are very significant, and when combined with Marshall's idea on knowledge spillovers, form the core model of localized technological development called the Marshall-Arrow-Romer (MAR) models (see Glesser et al. 1992). In short, the MAR model argues for (1) spatial agglomeration of firms in the same industry (within-industry knowledge spillovers) and (2) monopolistic competition as keys to regional industrial development.

How does clustering facilitate knowledge spillovers? In line with Marshall (1920), more recent studies also argue for the roles of geographical and sectoral proximities to facilitate knowledge spillovers, but a clear distinction is made between explicit knowledge (the kind of knowledge that can be codified and reduced to writing) and tacit knowledge (the kind of knowledge that is not codified or written). They show that spatial clustering of firms in the same industry is more conducive of spillovers of tacit knowledge (Lissoni 2001). As tacit knowledge is not easily transferred by any codification methods such as prescription, manual, and user guidance, acquisition and assimilation of knowledge of this kind requires gradual learning and direct experience. Clustering increases the chances that actors will have face-to-face interactions and thus helps firms obtain tacit knowledge through the processes of informal information exchange and mutual learning (Pavitt 1987 cited in Nelson 1989). Mytelka and Farinelli (2000) argue that when firms are clustered, they are more likely to establish inter-firm linkages which facilitate the spillovers of knowledge in a constrained locality.

One important characteristic of tacit knowledge is that it tends to flow within a specific locality rather than across distances. This is because tacit knowledge can be most efficiently acquired by learning-by-doing or learning-by-experiencing processes, which can be more easily facilitated by the industrial cluster in which actors are more likely to establish extensive face-to-face interactions (Dahl and Pedersen 2004; Chandra 2006). Additionally, some authors establish that knowledge spillovers in the cluster are facilitated by the so-called "relational capital" (i.e., market relationships, power relationships, and cooperation) established between firms, institutions, and people, which stems from a strong sense of belonging and a highly developed capacity for cooperation typical between culturally similar people and institutions (Capello and Faggian 2005).

The existence and importance of within-industry knowledge spillovers has also been endorsed by many empirical studies. Jaffe et al. (1993), using the citation of patent to proxy knowledge spillovers, observes that new patents are more likely to cite previous patents in the same metropolitan area or state than to cite more distant patents. This led them to the conclusion that knowledge is relatively localized. Baptista and Swann (1998), using the number of firms' innovations over the period 1975-1982, investigate whether the location of a firm in a region where the presence of firms in its own industry is strong has a positive effect on the number of innovations. They found that a firm is more likely to innovate in a location where sectoral agglomeration is strong, but found no significant effect of industrial diversification on innovation. This implies that intra-industry knowledge spillovers are more important than inter-industry knowledge spillovers to generate innovation. Yeo and No (2008) examine how a plant's probability of adopting a new technology depends on the presence of prior adopters. The results indicate that technology adoption is facilitated by the presence of prior adopters with four characteristics: first, they are prior adopters of the same technology; second, they reside in the same region; third, they are similar to the potential adopter in that they purchase a similar set of intermediate goods and services; and finally, they are dissimilar to the potential adopter in that they do not operate in the same product market. These empirical findings strengthen Marshall (1920)'s thesis that co-location of firms in the same industry generates knowledge spillovers.

Though the idea that industrial agglomeration is good for knowledge spillovers has been well established, a debate still continues regarding the internal structure of clusters to facilitate knowledge spillovers: of clustering of firms in the same industry (specialized industrial structure) or clustering of firms in different industries (diversified industrial structure), which one is more conducive for knowledge spillovers and technological development? There is much controversy over the MAR thesis, which generates a lot of discussion and counter-evidence (see Glaeser et al. 1992; Henderson et al. 1995; Panne 2004). In contrast with the MAR thesis, Jacobs (1969, 1981) argues that the key to development of the new work (i.e., product innovation and new technology) is a cross fertilization of ideas which are channeled through extensive interactions among diverse economic actors within cities. For Jacobs, in technological development, *diversity* is over greater importance than *specialization*. Cities with a mixture of different people and industries facilitate the exchange of different ideas, which is necessary for developing new products and innovations. Thus, industrial diversity in cities is relevant to the improvement of productivity and long-term growth. Porter (1990, 1998) disagrees with the ideas that monopolistic industrial structure will enhance innovative activities. He maintains that although competitive industrial structure may reduce the returns to innovations, competition among firms in the cluster will lead to a rapid acquisition of new ideas. Firms will be forced by competition from their rivals to develop innovation all the time in order to remain competitive, which leads to increasing knowledge spillovers and local industrial growth.

Theoretical work by Johansson and Forslund (2008) shows that firms and industries that benefit from input diversity experience an upstream externality, given that the inputs are distance-sensitive and hence can be purchased at a feasible price only if the inputs are delivered from suppliers in the proximity. Using the Cobb-Douglas production function in which one input-buying firm produces an output under a constant-to-return regime, it is shown that the output can be expanded when the number of input suppliers increases (Johansson and Forslund 2008, p.55). Moreover, in the model of customers' taste for diversity, it is also shown that large urban areas can generate a greater demand for variety than elsewhere. The import of low distance-sensitive goods requires a costly investment in import networks; and this can be motivated only by a sufficiently large demand. Also, to satisfy customers' demand for distance-sensitive goods, firms can maximize benefit by being proximate to customers (Johansson and Forslund 2008, pp.57-58).

Some empirical studies also find evidence supporting Jacobs's and Porter's view. For example, Glaeser et al. (1992) examines the growth of large (top six) two-digit industries in 170 U.S. cities between 1956 and 1978 and finds that local competition and urban variety encourage growth in industries. Henderson et al. (1995)'s study of high-tech firms also finds similar argument to that of Glaeser et al. (1992). Thus, it can be said that the "*diversity versus specialization*" debate still has been one of the most distinct debates in the body of literature on industrial clusters until recently.

2.3.2 Joint action and the concept of collective efficiency

A great contribution to the body of literature on industrial clusters comes from scholars who examine the dynamic process and growth of clusters, based on the case studies. These scholars (e.g., Kennedy 1999, Knorringa 1999, Nadvi 1999, Rabellotti 1999, and Schmitz and Nadvi 1999) argue that Mashallian externalities *per se* are not sufficient to explain clusters' growth. Therefore, they have proposed the idea of *collective efficiency* which is defined as the competitive advantage derived from (Marshallian) external economies and joint action (Schmitz and Nadvi 1999, p.1504).

Having focused on several cases of industrial clusters, some critical questions have arisen concerning why some clusters perform better than other clusters, why some firms in a cluster can manage to grow while other firms are in decline, and why some clusters can enjoy continuous growth over time while other clusters cannot. These questions cannot be explained merely by the Marshallian externalities framework. For clustered firms to enjoy steady growth, according to these scholars, they cannot only take agglomeration benefits passively. Rather, it is necessary for them to take joint actions (cooperative efforts made by firms in the cluster) (Schmitz and Nadvi 1999).

It is argued that Marshallian externalities are the passive dimension of collective efficiency, because they are assumed to be acquired by firms at cost; that is, firms can benefit from those externalities without making any further effort aside from locating in the cluster. On the other hand, joint action is seen as the active dimension of collective efficiency which requires that firms must establish deliberate and active cooperation with other firms in order to achieve collective and long-term growth (Nadvi 1999; Schmitz and Nadvi 1999).

Empirical evidence based on case studies in several countries confirms that cooperative efforts and joint actions are relevant to explain how firms in clusters can overcome challenges and problems common to them. Knorringa (1999) studied Agra footwear cluster in India which encountered many challenges during the early 1990s: a collapse of Agra's main export markets (Soviet Union), economic liberalization associated with the abandonment of government protection, tougher international competition, and a growing premium domestic market segment. He found that firms facing new competition, especially in export and high-end market segments, could manage to sustain growth. This is because they have engaged in selective joint action with similar local producers and relied on trust in their close cooperation with buyers and suppliers. Rabellotti (1999) also analyzes the impact of trade liberalization on firms in Guadalajara footwear cluster in Mexico and finds that the elimination of trade barriers and domestic protection and a large increase in shoe imports made firms aware of global competitive pressures. Many firms responded by increasing inter-firm cooperation. By increasing cooperation within the cluster, he argues, firms can increase their capability to grow. The regression model testing the effect cooperative behaviors on firms' performance also shows a significant positive relationship between the two.

In the investigation of how firms in Palar Valley tannery clusters in India responded to the new pollution regulation imposed by the Supreme Court, Kennedy (1999) found that cooperation facilitated by community ties and shared local identities enabled the clusters to meet the pollution crisis. She argued that although industrial clustering may help firms achieve collective efficiency by increasing the possibility that firms will interact and cooperate, this is not always the case. In order for firms in the cluster to cooperate and take collective actions, some forms of institution which generate norms, trust, and cooperative culture should exist. Additionally, Nadvi (1999)' s study on the response of the Sialkot surgical instrument cluster in Pakistan shows that, in response to the pressures posed by the quality assurance crisis, there has been upgrading in manufacturing practices in the cluster. Joint action, according to him, is the key to succeed in upgrading and improving firm performance. Greater cooperation with suppliers (called backward cooperation) and with customers (called forward cooperation) helps increase product quality and ensures that products meet standard requirements. Finally, he argued that competitive advantages cannot only be achieved by *passive* spillovers, but also by *active* cooperation.

The following studies suggest that co-location and cooperation dimensions of clustering can help firms acquire new knowledge and enhance their technological capacities.

- Clustering can help firms reduce uncertainty and risks associated with the process of acquisition or development of new ideas, technology, and innovation. Generally, technological and innovative activities are risky due to the complex and uncertain nature of such activities (Dosi 1988 cited in Caniels and Romijn 2001), and the outcome of such activities is also difficult to predict. In order to reduce uncertainties and risks, firms need access to useful information. In this case, clustering can facilitate access to information by increasing opportunities for firms and related institutions to communicate, interact, and cooperate (Baptista and Swann 1998).
- Technological development and innovation can be a very costly activity

especially for small firms. As the first step of acquiring new technology and innovation is costly and risky, clustering and networking are necessary for mobilizing resources. In this situation, costs and risks of technology and innovation development can be shared among small producers (Sandee and Rietveld 2001).[16]

- In terms of technological support, lessons from successful projects show that targeting groups of geographically clustered producers in the same industry, rather than scattered individual small companies with varied activities is more likely to achieve the goal. This is due to several reasons. First, it is more cost-effective for the supporting agencies to concentrate on the problems commonly faced by groups of producers in a few specific localities. Second, joint support can stimulate intra-firm learning through common problem-solving and information exchange. Moreover, firms can monitor each other's behavior which helps reduce monitoring cost and increases chance of success. Third, dealing with producers as a group can overcome contractual problems. This is especially important in the case that large firms (or public institutions) who are the clients of small suppliers are partnered in joint technological development projects such as Singapore's Local Industrial Upgrading Programme, Brazil` s SEBRAE Scheme, and Kenya's Farm Implements and Tools Programme (Romijn 2001).

2.4 Conceptual framework

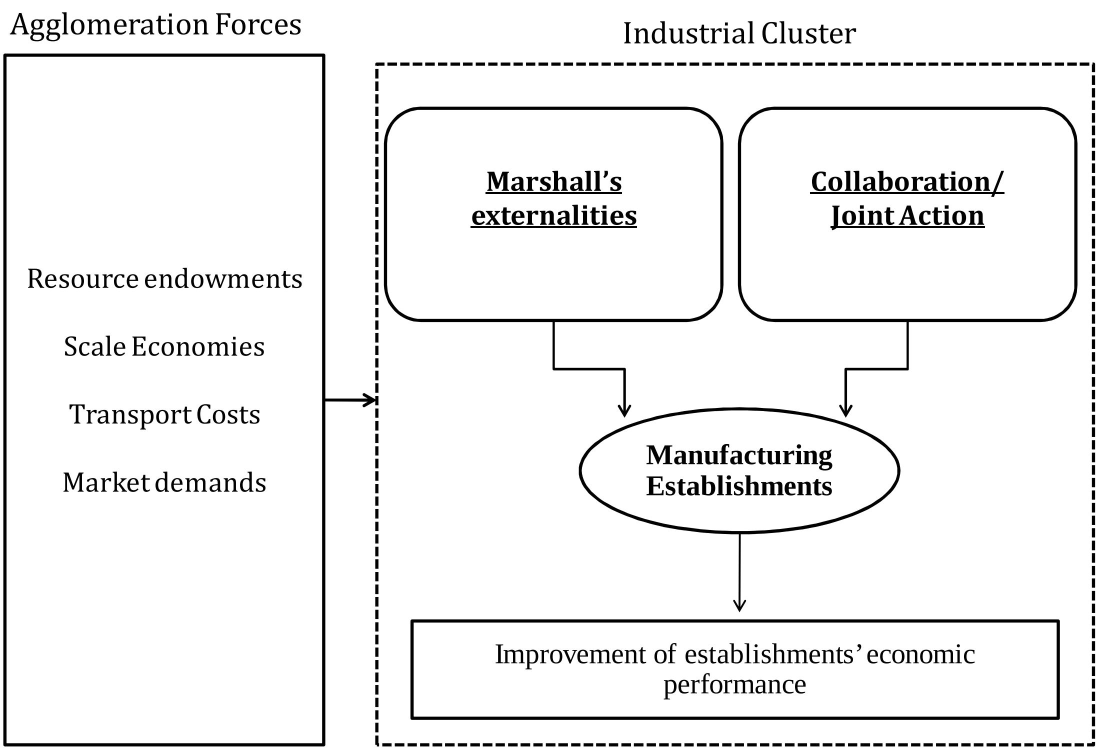
Based on the theories of firm location and industrial clustering, I develop a conceptual framework for use in this study, as presented in Figure 2.2. The box on the left-hand side

[16] DeBresson (1991) calls this phenomenon *network of innovators*.

consists of agglomeration forces discussed earlier. The four important elements that generate agglomeration forces include regional resource endowments, scale economies, transport costs, and market demands.

According to the resource-based approach, industries tend to be agglomerated in regions where they can utilize the resources necessary for their production. For instance, regions endowed with high skilled labor tend to exhibit a cluster of high-tech industry, while those endowed with natural gas and petroleum will be specialized in gas and petroleum industry.

Figure 2.2: Conceptual framework



Source: Author

The interactions between the three remaining forces in the box (scale economies, transport costs, and market demands) can also generate industrial agglomeration, according to the theory proposed by the NEG school of thought. When transport costs are large relative to establishment costs, manufacturing establishments tend to be located separately. If transport costs are extremely large, the economy will become autarchy in which small location produces everything for itself. Consequently, the whole economy cannot enjoy increasing returns to scale based on agglomeration economies. Thus, in a single economy where physical and institutional trade barriers are removed and goods, capital, and factors of production are allowed to flow freely, NEG expects industrial agglomeration and regional specialization as the consequences. And when agglomeration takes place in a particular region, it tends to reinforce and generate circular agglomeration forces. In the location with agglomeration of firms, demands for intermediate inputs will be large, helping intermediate producers to reach increasing returns. In addition, agglomeration of establishments attracts labor which, in turn, generates demand for consumption of goods.

The box on the left-hand side denotes agglomeration forces which are generated by the interactions between the elements in the box. These agglomeration forces generate the geographical and sectoral agglomeration of manufacturing establishments (or industrial cluster) as predicted by NEG. Industrial cluster contains the sectorally related establishments, and the co-location of these establishments produces the so-called Marshallian externalities including labor market pooling, specialized inputs suppliers, and spillovers of knowledge and information.[17] Manufacturing establishments can benefit from Marshallian externalities simply by being located in the industrial cluster. In other words, when establishments are located in the cluster, benefits in terms of labor market pooling, availability of specialized

[17] Some scholars (e.g., Krugman 1991a, Glaeser et al. 1992) call them *localization economies*. Thus, very often, Marshallian externalities and localization economies are used interchangeably.

inputs suppliers, and knowledge spillovers will *automatically* accrue to them (Schmitz and Nadvi 1999).

However, it has been argued that Marshallian externalities *per se* are not sufficient to explain the long-term success of establishments in industrial clusters (Schmitz and Nadvi 1999). Manufacturing establishments may benefit from Marshallian externalities by being co-located with their neighbors, but those externalities alone are not enough to help establishments sustain their competitiveness, especially when they face new challenges and threats. In order to overcome challenges and threats and enjoy sustainable growth, establishments in the cluster need to have some form of collaboration and joint actions. Thus, in the cluster, interactions between Marshallian externalities and collaboration/joint action are relevant to explain the improvement of establishments' performance (e.g., productivity growth, technological upgrading, and sales growth). The important assumption here is that clustered firms engaging in active collaboration with their neighbors tend to be better-off than those passively waiting for benefits from Marshallian externalities only (Ibid.).

In the context of this study, the conceptual framework presented in figure 2.2 is applied as follows. First, in Chapter 4, I test the effects of agglomeration forces on existence of industrial clusters and the formation of industrial clusters. Elements in the left-hand side box are statistically examined as to whether they affect the manufacturing establishments' decision to be located in industrial clusters and in emerging clusters,[18] taking some characteristics of establishments into account such as establishment size, foreign share, export, organization of production, and ownership structure.

Second, the effects of industrial clustering on manufacturing establishments (the

[18] Unfortunately, transport costs cannot be statistically tested in this study, because the data on transport costs are incomplete. In my data set (industrial census 2007), missing values of manufacturing establishments' transport costs account for more than 60%, which potentially affects the validity of the test. Hence, I decided not to include transport costs in the analysis of establishments' location in this study.

dotted box on the right-hand side of Figure 2.2) are examined in Chapter 5 and Chapter 6. In Chapter 5, I statistically analyze whether the co-location of related manufacturing establishments improve establishments' labor productivity. The assumption made for this test is that the co-location of related establishments generates Marshall's externalities and increases the chances that establishments will collaborate with each other, which may translate into the improvement of establishments' labor productivity.[19] The statistical analysis takes into account the variation in spatial and sectoral scopes of agglomeration. This is based on the logic that differences in spatial and sectoral scopes of agglomeration can generate different possibilities that establishments will collaborate with each other. For instance, the spatial agglomeration of broad-range and complementary activities may be more conducive for manufacturing establishments to establish business linkages and collaboration with each other than the spatial agglomeration of narrow-range activities.[20]

It should be noted that a statistical analysis in Chapter 5 can only show: (1) whether industrial clustering is good for establishments' labor productivity; and (2) at what spatial and sectoral scopes that clustering may result in the improvement of establishments' labor productivity. Such statistical analysis cannot say *why* and *how* clustering may generate good outcomes. Therefore, a case study analysis is taken to address these questions. In Chapter 6, a case study of PTC silk-weaving industry is used to investigate why and how clustering may help establishments improve their economic performance. Based on the conceptual framework presented in Figure 2.2 (the dotted box on the right-hand side), it is argued that for establishments in the industrial cluster to enjoy sustainable growth, the combination between

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[19] It should be noted that each element in Marshall's externalities (labor market pooling, availability of specialized input suppliers, and knowledge spillovers) cannot be examined separately due to the lack of data. I note this as the limitation of this study.

[20] For instance, spatial agglomeration of the textile industry which include such complementary activities as yarn-dyeing, yarn-spinning, weaving, fabric printing, and garment making can be more conducive for business linkages than spatial agglomeration of weaving activity alone.

Marshall's externalities (generated by the co-location of establishments in the same sector) and collaboration/joint action is needed (Schmitz and Nadvi 1999). Note that the arrows running downward from the boxes "Marshall's externalities" and "collaboration/joint action" to the box "manufacturing establishments" indicate that, for establishments to improve their economic performance, *both* Marshall's externalities and collaboration/joint action are necessary. According to Schmitz and Nadvi (1999), in the absence of collaboration/joint action, establishments may not be able to overcome challenges/risks and enjoy sustainable growth.

I examine this thesis as follows. First, I divide the historical development of PTC silk-weaving industry into two periods. The first period (1967-1997) is the period when some PTC producers established vertical linkages and close collaboration with their co-located buyer. The second period (after 1997) is the period when vertical linkages and collaboration between PTC producers and their co-located buyer is absent, and PTC producers have been facing such challenges as increased prices of raw materials and intense competition. Second, I compare the business relations and performance of PTC producers between these two periods and examine whether the presence of collaboration/joint action (between 1967 and 1997) and absence of collaboration/joint action (after 1997) result in different economic outcomes.

Chapter 3

Geographic Concentration of Thai Manufacturing Industries

3.1 Introduction

Manufacturing industries in Thailand have long been recognized for their unequal spatial distribution: the great majority of manufacturing establishments have been concentrated in Bangkok and its surrounding provinces, while a small number of establishments have been sparsely distributed across peripheral provinces. This phenomenon is said to be caused, at least in part, by unbalanced regional development policies in favor of urban areas (see Siamwalla and Setboonsarng 1989; Krongkaew 1995; Kittiprapas 1999). On the other hand, some studies argue that the geographic concentration is mainly caused by the advantages of Bangkok and its nearby provinces in terms of large demand for both input and final products, abundance of labor, well-developed infrastructure, and proximity to export-import markets. These factors make Bangkok and its nearby provinces more attractive to firms than any other locations in the country and thus explain a large concentration of industries in Bangkok and surrounding provinces (World Bank 1983, Bigs et al. 1990, Tambunlertchai 1993, Poapongsakorn 1995, Kittiprapas 1999).

Though the issue of geographic concentration of Thai manufacturing industries has been examined widely in the past two decades, the previous studies have not yet captured two important aspects of such concentration. First, most previous studies have not sufficiently examined how concentration has evolved over time. Prior studies have mainly relied on static analysis of concentration, thus ignoring its dynamic aspect. Second, none of the previous studies has focused on the sectoral aspect of geographic concentration. They mainly focused on the overall geographical distribution of the manufacturing industry but ignored how industries of different characteristics have been spatially distributed. If we assume that each industry has different competitiveness elements (e.g. price, design, and materials used), then the geographic distribution of each industry may exhibit some differences. These two aspects are captured in this chapter.

The discussion on industrial concentration in this chapter provide some background information on the spatial clustering in Thai manufacturing industries that are examined in Chapter 4. The main purpose of this chapter is to provide an overall picture about the degree of geographic concentration and the change in the extent of concentration at the industrial level. This chapter does not delve into the details of where or in what locations manufacturing establishments are clustered. It shows which industries exhibit high geographic concentration and how spatial adjustment at the industrial level has occurred. This information is necessary for the discussion on industrial clustering that is be presented in Chapter 4.

This chapter is organized as follows. Section 3.2 discusses how geographic concentration of the manufacturing industry is measured. It gives a brief explanation about the data employed in the analysis as well as the measure used. Section 3.3 empirically shows how geographic concentration of Thai manufacturing industries has evolved over time with respect to industrial characteristics. This section also discusses spatial adjustment of manufacturing industries during the period studied. Section 3.4 concludes the chapter.

3.2 Measuring manufacturing industrial concentration

3.2.1 Data

The data employed in this chapter are derived from two censuses of manufacturing industries conducted in 1996 and 2006 and published in 1997 and 2007 by the National

Statistical Office of Thailand (NSO). These data sets contain important information on characteristics of manufacturing establishments in Thailand (e.g., geographical location, industrial sector, year of establishment, ownership structure, fixed assets, number of workers, production costs, sales, value added, import and export). The numbers of manufacturing establishments in the 1997 and 2007 census data sets are 32,489 and 73,931, respectively.

The collection of data on manufacturing establishments took place between June and September of 1996 and of 2006.[21] Therefore, these data contain information on manufacturing establishments that existed between June and September of both years.[22]

The NSO's manufacturing industrial census data have some advantages over other alternative data sources such as the Office of Industrial Economics (OIE)'s industrial survey and the Department of Industrial Work (DIW)'s factory data. First, the data from the census consist of more detailed information on establishment characteristics (e.g., geographical location of establishment, form of legal organization, number of workers, fixed assets, foreign investment, and purchase of inputs) and other performance indicators (e.g., sales, profits, value added, export, and R&D investment). Second, the census represents the entire population of manufacturing establishments, not just a sample of establishments as in the survey data. Thus, the census has a wider coverage. Finally, the census data are more accessible to researchers. It can be purchased under the contract terms. The OIE's firm-level data are confidential, only aggregate data at industry levels are provided. However, as the census is conducted every ten years, the problem of using census data is that we might lose some information about industrial restructuring and changes occurring between censuses.

The census data are territorially disaggregated in accordance with administrative

[21] Prior to the nationwide manufacturing census, censuses of other economic activities (service, trade, construction, and transportation) were also conducted.

[22] Before 1996, an industrial census was conducted once in 1964. However, the 1964 census data are in many aspects not consistent with the 1997 and 2007 census data sets, especially in terms of coverage and definition of key variables. Thus, it is not used in this study.

units; these units include district (*Amphor*), province (*Changwat*), and region. This chapter uses the province as a territorial unit of analysis in order to make the result comparable with previous studies on Thai industrial location; such studies have taken the province as the unit of analysis. The number of provinces is 76 for both the 1997 and the 2007 census data sets.[23] The list of provinces and the number of provincial manufacturing establishments are provided in Appendix 3.1.

In the census data set, manufacturing industries are disaggregated based on the International Standard Industry Classification (ISIC) code and consist of manufacturing establishments at the 2-digit, 3-digit, and 4-digit levels. The numbers of industries are 23, 59, and 124 for 2-digit, 3-digit, and 4-digit groups, respectively (see Appendix 3.2 for the list of 2-digit and 3-digit industries). To avoid unnecessary confusion, the analysis of geographic concentration in this chapter is of 2-digit industry groups only. However, as complementary information, the analysis of the concentration at the 3-digit level is provided in the appendix. The geographic concentration in 4-digit industries is not analyzed here because at this level the data become too geographically sparse to yield significant conclusions.

3.2.2 Measure used

There is considerable debate about how to measure geographical concentration of industries. Various indices have been proposed and used, each with specific advantages and disadvantages.[24] In this study, I employ the locational Gini index which is a standard measure widely used in the literature.[25]

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[23] In Thailand, the number of provinces can be changed due to the establishment of a new province. For example, between 1977 and 1993, Thailand had 73 provinces. In December, 1993, three districts were promoted to the status of province, and thus the number is 76 now.
[24] See Overman et al. 2003, Combes and Overman 2004, and Combes et al. 2008 for an extensive review of widely-used industrial concentration indices and a detailed discussion on properties of each index.
[25] The locational Gini index (together with other indices such as Hirschman-Herfindahl Index,

The locational Gini index (or alternatively, Gini coefficient) measures the extent to which regional share of industry (say, sector *i*) deviates from the expected share under a uniform distribution.[26] For each manufacturing industry sector *i*, the Gini index is constructed by ranking, in ascending order, the share of establishments in sector i $(i = 1,2,\ldots,I)$[27] and region r $(r = 1,2,\ldots,R)$[28] in sector *i*'s total establishments:

$$\boldsymbol{S}_{ir} = \boldsymbol{E}_{ir} / \Sigma_r \boldsymbol{E}_{ir}$$

where $\boldsymbol{E}_{ir}$ is the number of establishments in sector *i* and region *r*, and $\Sigma_r \boldsymbol{E}_{ir}$ is the total establishments in sector *i*. Graphically, the Gini index is the area between the *Lorenz* curve and the 45º line through the origin. In this case, the 45° line represents a uniform distribution that would exist if all regions received an equal share of manufacturing establishments in sector *i*. The *Lorenz* curve is produced by plotting $\boldsymbol{S}_{ir}$ values in ascending order and then drawing a line to connect those values. In the graph, the x-coordinate represents the cumulative share of establishment in sector *i* of each region under the assumption of uniform distribution (i.e., each region has *1/R* share), while the y-coordinate represents the cumulative share of these *R* regions in total establishments. In this study, the Gini index is calculated

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Concentration Ratio, and Coefficient of Variation) have been criticized for not being able to distinguish between random and non-random distributions. To address this problem, Ellison and Glaeser (1997) have developed a concentration index based on the so-called *dartboard approach* which compares industrial distributions arising from two processes: one is the distribution arising from random process, another one is the distribution arising from agglomerative forces or natural advantages. However, this index is proved to be biased when the number of establishments is used as a measurement unit; particularly, when establishment counts are less than the number of regions, which is the case in my study (see Kim et al. 2000 for a further elaboration). Therefore, in empirical studies which apply Ellison-Glaeser index, researchers always use employment (i.e., number of workers) as a unit of measurement (see Ellison and Glaeser 1999, Rosenthal and Strange 2001, Dumais et al. 2002, Hjelm and Borgman 2004, Holmes and Stevens 2004, Bertinelli and Decrop 2005, and Breschi 2008).

[26] Note that this statement is about the property of *absolute* Gini index. An alternative type of Gini index measures geographical concentration of industry in a *relative* sense. That is, it measures the extent to which regional share of industry *i* deviates from its national share. In this study, I use *absolute* Gini index because it reflects absolute inequality in a distribution of establishment across provinces. Using *relative* Gini index may result in spurious concentration when the share of industry *i* in total economy is relatively small.

[27] Based on ISIC classification, there are 23 2-digit and 59 3-digit manufacturing industries in Thailand. Hence, I = 23 and I = 59 for 2-digit and 3-digit industries, respectively.

[28] Note that, in this study, the regional unit of analysis is province. Thus, R = 76.

using the following formula:

$$\left|1 - \sum_{n=1}^{R} \frac{1}{R}\left(S_{ir(n-1)} + S_{ir(n)}\right)\right|$$

where *n* is the number of regions ranging from 1 to *R*, and $\boldsymbol{S}_{ir\,(0)} = 0$.

The interpretation of the Gini index is quite straightforward: if the establishments in sector *i* are equally distributed across all regions, each region would have *1/R* share of total establishments in sector *i*. In this case, the *Lorenz* curve would lie on the 45° line, and there would be no area between the line of equailty and the *Lorenz* curve. The more the establishments are unequally distributed, the more the *Lorenz* curve deviates from the 45° line, and the larger the area between this curve and the line of equality. This means that the region with the largest share of establishment in sector *i* has a share of establishment larger than *1/R*, and the first two regions with the largest share have a combined share that is larger than *2/R*. The Gini index lies between zero and one. The index takes the value of zero in cases of perfect equality, and one in cases of perfect inequality.[29]

Using the Gini index, I calculated the geographic concentration for 23 2-digit and 59 3-digit manufacturing industries in the years 1996 and 2006. In the following section, I discuss the calculation results for 2-digit sectors. The results for 3-digit sectors are given in the appendix.

3.3 Geographic concentration of Thai manufacturing industries

3.3.1 Industrial category

In order to present and discuss the results in a simple way, I group 23 2-digit industries

[29] See Combes et al. (2008) for a discussion about absolute Gini index, and also Hoover (1936) and Isard et al. (1998) for a Gini-like measure called *Localization Curve* which relies on a similar procedure to measure the extent to which the industry is concentrated in some locations.

into four categories. The grouping is based on Yokota's (2008, pp.228-230) categorization of Thai manufacturing industries. Yokota (2008) uses the data from Thailand's Input-Output tables for the years 1995, 1998, and 2000 to calculate the extent to which (natural) resources, machineries, and labor are used as inputs for each industry. He ranks manufacturing industries based on the degree that these inputs are used in each industry, and comes up with four industrial groups. Based on Yokota's (2008) categorization, this study groups 23 2-digit industries as follows:

1. Resource-based industry: food products and beverages (ISIC15), tobacco products (ISIC16), woods and products of wood (ISIC20), coke and refined petroleum products (ISIC23), rubber and plastic products (ISIC25), other non-metallic mineral (ISIC26);
2. Labor-intensive industry: textiles (ISIC17), wearing apparels and dressing (ISIC18), leather and leather products (ISIC19), publishing, printing and reproduction of records (ISIC22), basic metals (ISIC27), furniture (ISIC36), and recycling (ISIC37);[30]
3. Machinery industry: machinery and equipment n.e.c. (ISIC29), office, accounting and computing machineries (ISIC30), electrical machineries and apparatus (ISIC31), radio, television and communication equipments (ISIC32), medical, precision and optical instruments, watches and clocks (ISIC33), motor vehicles, trailers and semi-trailers (ISIC34), other transport equipments (ISIC35); and

[30] In Yokota (2008), recycling industry is excluded from the categorization due to the insufficiency of data in I-O tables. In this study, I include this industry in the labor-intensive group. This is because based on 2007 census data, recycling is one of five industries with the lowest capital investment relative to labor (capital-labor ratio).

4. Metal, chemical, and paper industry: paper and paper products (ISIC21), chemicals and chemical products (ISIC24), and fabricated metal products (ISIC28).

Note that the last group includes three manufacturing industries - paper and paper products (ISIC21), chemicals and chemical products (ISIC24), and fabricated metal products (ISIC28) – which are characterized by relatively low resource ratios, low machinery input ratios, and low labor-intensiveness, as compared to other industries.[31] Thus, each of these industries cannot be categorized as resource-based, labor-intensive, or machinery industry. I name this group after the industries included in the group as "metal, chemical, and paper". Hereafter, this industry group is called MCP for simplicity.[32]

3.3.2 Empirical evidence of industrial concentration

a. Level of geographic concentration

What industries exhibit a high level of geographical concentration? Based on Gini coefficients calculated for all 2-digit industries, it is found that the industries that exhibit the highest level of concentration are those belonging to the machinery industry group, followed by MCP, and labor-intensive groups. Industries that register the lowest degree of concentration are those from resource-based industry groups.

Table 3.1 shows the ranking of 2-digit industries (in descending order) with respect to their average Gini coefficients between 1996 and 2006 (similar information on 3-digit

[31] For example, the paper and paper products industry (ISIC21) has a labor-input ratio of 0.078, much lower than the publishing, printing and reproduction of records industry (ISIC22) which is ranked at the bottom of the labor-intensive industry group and has a labor-input ratio of 0.161. See Yokota (2008, pp.228-230) for more details.

[32] In Yokota (2008), this group is called "metal and chemical industry". However, as this name does not represent the paper and paper products industry, which is one of the industries in this group, I call it "metal, chemical, and paper" instead.

industries is provided in Appendix 3.3). As seen from the table, the top-seven most concentrated industries are office, accounting and computing machineries (ISIC30), tobacco products (ISIC16), paper and paper products (ISIC21), radio, television and communication equipments (ISIC32), electrical machinery (ISIC31), leather and leather products (ISIC19), and medical, precision and optical instruments (ISIC33). In fact, four of these industries belong to the machinery industry group (ISIC30, ISIC31, ISIC32, and ISIC33), while the other three industries – ISIC21, ISIC16, and ISIC19 – belong to MCP, resource-based, and labor-intensive groups, respectively. On the other hand, industries that register a very low degree of concentration are (in ascending order of concentration) food products and beverages (ISIC15), mineral products (ISIC26), wood and products of wood (ISIC20), furniture (ISIC36), fabricated metal products (ISIC28), textile (ISIC17), and wearing apparel (ISIC18). Most of these industries are from resource-based and labor-intensive groups.[33]

[33] The ranking of average Gini coefficient at the 3-digit level is fairly consistent with that at the 2-digit level. The top ten least concentrated industries are those belonging to resource-based and labor-intensive groups of industries including production and processing of meat, fish, fruit, vegetables, oils and fats (ISIC151), dairy products (ISIC152), grain mill products (ISIC153), other food products (ISIC154), beverages (ISIC155), wood products (ISIC202), non-metallic and mineral products (ISIC269), furniture (ISIC361), and manufacturing of furniture n.e.c. (ISIC369). The exception is structured metal products (ISIC281) which belongs to MCP group. On the other hand, in the top ten most concentrated industries, seven are in the machinery group (i.e., electricity distribution and control apparatus (ISIC312), insulated wire and cable (ISIC313), accumulators, primary cells and batteries (ISIC314), electric lamp (ISIC315), optical instruments and photographic equipment (ISIC332), watches and clocks (ISIC333), and aircraft and spacecraft (ISIC353)). The consistency between 2-digit and 3-digit results indicates that the Gini index is consistent across industrial aggregation.

Table 3.1: Ranking of average Gini coefficient for 2-digit industries, 1996-2006

2-digit			2-digit		
ISIC	**Gini (Average)**	**Rank**	**ISIC**	**Gini (Average)**	**Rank**
ISIC15	0.383	23	ISIC27	0.832	8
ISIC16	0.885	2	ISIC28	0.659	19
ISIC17	0.677	18	ISIC29	0.755	15
ISIC18	0.688	17	ISIC30	0.901	1
ISIC19	0.836	6	ISIC31	0.861	5
ISIC20	0.502	21	ISIC32	0.864	4
ISIC21	0.873	3	ISIC33	0.835	7
ISIC22	0.770	14	ISIC34	0.828	11
ISIC23	0.829	10	ISIC35	0.783	13
ISIC24	0.740	16	ISIC36	0.603	20
ISIC25	0.829	9	ISIC37	0.817	12
ISIC26	0.420	22			

Source: Author's calculation

Table 3.2 supplements information relevant to the above finding. The average Gini coefficient calculated with respect to industry category shows that as the industry category moves from resource-based to machinery, the average Gini coefficient increases. In fact, MCP and machinery groups have average Gini coefficients higher than the grand mean (i.e., average Gini coefficient for all industries), thus industries belonging to these two categories tend to possess a high degree of concentration between 1996 and 2006.

Table 3.2: Average Gini coefficient by industrial category, 1996-2006

Industrial category	**Average Gini (1996-2006)**
Resource-based	0.641
Labor-intensive	0.715
MCP	0.784
Machinery	0.833
Grand mean	0.746

Note: MCP = metal, chemicals, and paper industries
Source: Author's calculation

It should be noted also that there exist some variations in the degree of concentration within each industry category. For example, some industries in the resource-based group (i.e., ISIC16 and ISIC23) and in the labor-intensive group (i.e., ISIC19) are ranked among the top ten most concentrated industries, although the concentration of resource-based and labor-intensive categories, in general, is relatively low as compared to the other two categories. In fact, the Gini values of these industries are even higher than the grand mean of Gini. More variations occur as we move from the 2-digit to the 3-digit industrial level (see Appendix 3.3). At the 3-digit level, there are more resource-based and labor-intensive industries which exhibit higher geographical concentration than machinery and MCP industries. This variation indicates specific industrial characteristics which make some industries more geographically concentrated than overall expectation.

Note also that the Gini coefficient tends to inflate as the level of industrial disaggregation increases. Average Gini coefficients for each industrial category are higher at 3-digit level (see Appendix 3.4). For example, average Gini coefficients for resource-based, labor-intensive, MCP, and machinery industries for 3-digit industries are 0.650, 0.778, 0.808, and 0.877, respectively. These are larger than those numbers in Table 3.2. This happens because the number of industrial establishments is smaller for more disaggregated industrial level and, consequently, tends to be concentrated in some provinces. This is particularly true for the industrial sector that has a fewer number of establishments than the number of provinces, in which case there will be some provinces with no establishment in that sector. Thus, with further industrial disaggregation, the number of establishments in the industrial sector gets smaller, and the value of the Gini coefficient increases.[34]

b. Changes in geographic concentration

Changes in geographic concentration occur very rapidly in resource-based and labor-intensive industries but very slowly in machinery and MCP industries. Table 3.3 shows the changes in the Gini coefficient of Thai manufacturing industries from 1996 to 2006. It is obvious from this table that geographical concentration in Thai manufacturing industries, in general, had a downward trend during the period between 1996 and 2006. The degree of concentration dropped in every sector. The average decrease in Gini coefficient for all 2-digit manufacturing industries was 23.8% during this period (or about 2.4% per year). Industries that show a rapid decrease in degree of concentration are wood and wood products (ISIC20), fabricated metal products (ISIC28), wearing apparel (ISIC18), furniture (ISIC36), foods and beverages (ISIC15), and textiles (ISIC17) whose Gini coefficient dropped more than 40% between 1996 and 2006. These industries belong to resource-based and labor-intensive groups with a low level of geographical concentration. On the other hand, industries whose geographical concentration decreased very little during this period are motor vehicles

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[34] Spearman's bivariate correlations between number of establishment and Gini coefficient (at 3-digit industrial level) are -6.55 and -8.36 for 1996 and 2006, respectively (both are statistically significant at one percent).

(ISIC34), coke, refined petroleum, and nuclear fuel (ISIC23), office machineries (ISIC30), rubber and plastic products (ISIC25), and radio, TV and communication equipments (ISIC32). For these industries, Gini coefficients dropped less than 10%. These facts indicate that resource-based and labor-intensive industries were not only more geographically dispersed than MCP and machinery industries, but their dispersal rates were also more rapid. However, an exception should be made for such resource-based industries as coke, refined petroleum, and nuclear fuel (ISIC23) and rubber and plastic products (ISIC25) whose level of geographical concentration was high and deconcentration rate was very low.[35]

[35] The results obtained from 3-degit industrial classification do not differ much from those obtained from 2-digit classification (see Appendix 3.5). The degree of spatial concentration decreased in almost all sectors during the period 1996-2006, as indicated by the minus sign of Gini coefficients. The average change in Gini coefficients for all 3-digit sectors is -18.9. It can be seen from Appendix 3.5 (last column) that spatial deconcentration took place very quickly in many sectors, especially in resource-based sectors (such as production, processing and preservation of meat, fish, fruit, vegetables, and oils and fats (ISIC151), dairy products (ISIC152), grain mill products and animal feeds (ISIC153), other food products (ISIC154), and beverages (ISIC155)) and labor intensive sectors (such as other textiles (ISIC172), wearing apparels (ISIC181), furniture (ISIC361), and furniture n.e.c. (ISIC369)). On the other hand, spatial deconcentration happened very slowly in such industries as office machineries (ISIC300), electricity distribution and control apparatus (ISIC312), accumulators and primary cells and batteries (ISIC314), electric lamps (ISIC315), and other electrical equipments (ISIC319), and electronic valves, tubes and components (ISIC321), which belong to machinery group. There are only three sectors, namely, dressing and dyeing of fur (ISIC182), watches and clocks (ISIC333), and motor vehicles (ISIC341) that increased their degree of concentration during the period studied.

Table 3.3: Changes in Gini coefficients

	Gini coefficient		
2-digit industries	**1996**	**2006**	**Change (%)**
ISIC15	0.495	0.271	-45.3
ISIC16	0.936	0.833	-11.1
ISIC17	0.851	0.503	-40.9
ISIC18	0.900	0.476	-47.1
ISIC19	0.666	0.338	-49.2
ISIC20	0.919	0.827	-10.0
ISIC21	0.913	0.627	-31.4
ISIC22	0.842	0.815	-3.2
ISIC23	0.864	0.615	-28.8
ISIC24	0.858	0.800	-6.8
ISIC25	0.481	0.359	-25.5
ISIC26	0.898	0.766	-14.6
ISIC27	0.871	0.446	-48.7
ISIC28	0.887	0.623	-29.7
ISIC29	0.918	0.885	-3.5
ISIC30	0.906	0.816	-10.0
ISIC31	0.895	0.833	-6.9
ISIC32	0.926	0.744	-19.7
ISIC33	0.829	0.827	-0.3
ISIC34	0.891	0.675	-24.2
ISIC35	0.788	0.418	-46.9
ISIC36	0.926	0.708	-23.6
ISIC-37	0.926	0.708	-23.6

Source: Author’s calculation

Another important observation from Table 3.3 is that Gini coefficients tend to decrease more rapidly in those sectors which exhibited lower Gini values in 1996. For example, ISIC15, ISIC20, ISIC26, and ISIC36, whose Gini coefficients were relatively low in 1996, are industries that registered a larger drop in Gini coefficient; on the other hand, ISIC16, ISIC19, ISIC33, and ISIC37, which had high Gini coefficients in 1996, registered a smaller drop in Gini coefficient. Thus, the geographical decentralization process of Thai manufacturing industries tends to be faster for industries that were already more equally distributed. This process can be explained by two related phenomena: firstly, between 1996 and 2006, the number of establishments increased considerably in the less concentrated sectors (e.g. ISIC15, ISIC17, ISIC18, ISIC28, and ISIC36); secondly, new establishments in these sectors were established in other locations, rather than in the already-agglomerated areas. On the other hand, in some highly concentrated sectors the number of establishments either decreased (i.e. ISIC16, ISIC30, and ISIC34) or increased very modestly (e.g. ISIC21 and ISIC32) (change in the number of establishments in each industry is given in Appendices 3.6 and 3.7). Even if the number of establishments increased in some highly concentrated sectors, new establishments in these sectors did not choose locations which had no existing sector presence. This issue is elaborated more in the following sub-section.

c. Spatial adjustment of Thai manufacturing industries

This subsection discusses the spatial adjustment of Thai manufacturing industries, as complementary information to the above discussion. In the previous subsection, we have seen that the overall spatial concentration of Thai manufacturing industries had declined over time from 1996 to 2006. In other words, Thai manufacturing industries, in general, have moved toward a more even distribution across provinces, despite some variations in the degree of spatial deconcentration across industries. Now, we need to elaborate some more on how this phenomenon has happened.

Table 3.4 shows the regional distribution of Thai manufacturing establishments from 1981 to 2006 in terms of the number and percentage share. The data used in Table 3.4 are derived from the Department of Industrial Works (DIW)'s factory data. This data contains the number of the registered factories that use the machines with at least five horsepower engines or have at least seven workers.[36] Figure 3.1 supplements Table 3.4 by presenting the changes in the number of manufacturing establishments in each region. In Table 3.4, the Bangkok Metropolitan Region (BMR) – the largest industrial agglomeration area in Thailand – is divided into two parts: the city of Bangkok and the Inner Ring area (Nonthaburi, Nakhon Pathom, Pathum Thani, Samut Prakan, and Samut Sakhon) (see Appendix 3.8). The reason for such a division is to clearly see the movement of industries between Bangkok city and other provinces in the BMR.[37]

It can be said that, the city of Bangkok, with an area of only 0.31% of the country's total area, was the main industrial center of Thailand at least until 1991. The share of manufacturing establishments in Bangkok was more than 40% until the late 1980s. The manufacturing establishment share of Bangkok reached its peak in 1985, in which its share was 45.1%. In 1991, its share was still as high as 36.5% (or more than one-third of the whole kingdom). However, after 1991, its share dropped significantly (e.g. from 36.5% in 1991 to 16.5% in 1995). And in 2006, the share of Bangkok's manufacturing establishments was only 15.3%. With a steady decline of Bangkok's establishment share, we can say that Bangkok has been losing its relative importance as an industrial center of the country.

Along with the decline in Bangkok's establishment share, the number of

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[36] I use the DIW's factory data here because it has a longer time coverage than the NSO's industrial census data. As the purpose of this subsection is to provide the information on the regional distribution of Thai manufacturing establishments since the beginning 1980s onward, the DIW's factory data are needed. Note that the number of establishments provided by DIW and NSO may not be consistent for some reasons. First, the definition of manufacturing establishments used by DIW differs from that used by NSO. For DIW, manufacturing establishments refer to workshops that use machines with at least five horsepower engines or have at least seven workers. But for NSO, manufacturing establishments refer to workshops with at least one employee. Second, while DIW' factory data is based on the registration of establishments in each year (not accounting for those that cease operating), NSO's census data report the number of manufacturing establishments operating at the time that the census was conducted.

[37] The Bangkok Metropolitan Area (BMR) covers an area of 7,761.5 Km^2. Its population and population density in 2007 were 9,983,685 persons and 1,286.3 persons/Km^2, respectively (see Appendix 3.8). The BMR is an economic area rather than an administrative area. It can be distinguished from the Bangkok Metropolitan Administration (BMA) which covers only the city of Bangkok. Each province in the BMR is an administrative unit, and they are independent from each other in terms of administrative authority.

establishments in Bangkok has also declined during the period 1981-2006. The number of establishments increased from 17,318 in 1981 to 20,817 in 1991, and then dropped to 11,150 and 11,997 in 2001 and 2006, respectively. The decline in the number of establishments in Bangkok during the period 1981-2006 reflects the higher costs of locating plants in this city.

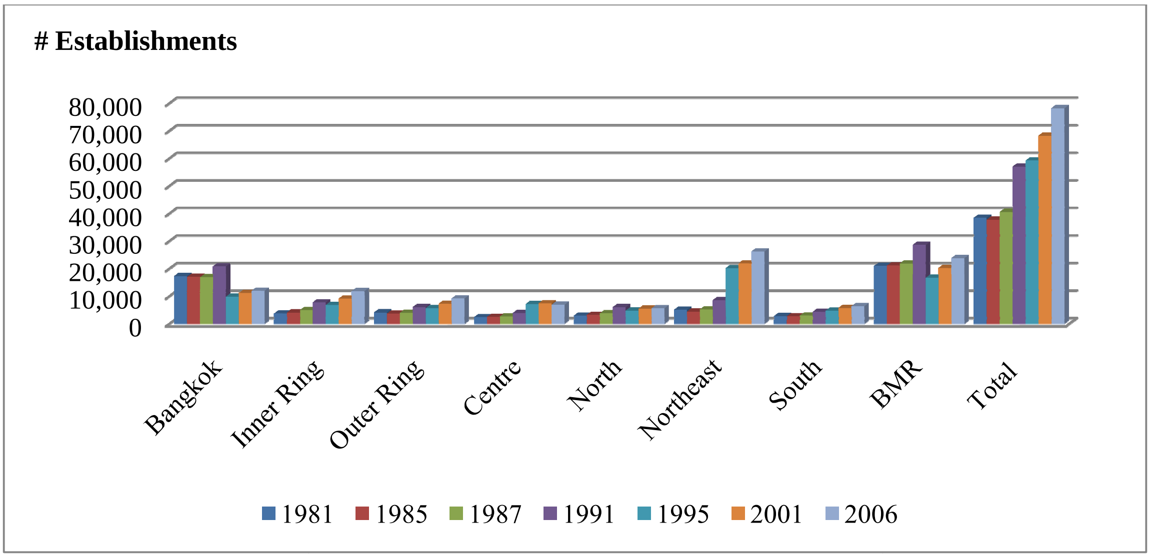
In contrast to Bangkok, other areas exhibit a significant growth in the number of establishments between 1981 and 2006 (as shown in the last column of Table 3.4). The Inner Ring area, which accounts for 1.2% of the country's area, is the second most industrialized area in Thailand, behind only Bangkok. Its importance as the country's industrial center has been obvious since the mid-1980s when the number and share of establishments in Bangkok started to decline (Figure 3.2).

Table 3.4: Regional distribution of Thai manufacturing establishments, 1981-2006

	1981	**1985**	**1987**	**1991**	**1995**	**2001**	**2006**
Bangkok	17,318	17,017	16,918	20,817	9,836	11,150	11,997
	(45.0)	(45.1)	(41.7)	(36.5)	(16.6)	(16.3)	(15.3)
Inner Ring[1]	3,732	4,116	4,972	7,802	6,856	9,140	11,835
	(9.7)	(10.9)	(12.3)	(13.7)	(11.6)	(13.4)	(15.1)
Outer Ring[2]	4,132	3,697	3,986	6,091	5,672	7,242	9,190
	(10.7)	(9.8)	(9.8)	(10.7)	(9.6)	(10.6)	(11.8)
Centre	2,409	2,466	2,675	3,924	7,160	7,465	6,960
	(6.3)	(6.5)	(6.6)	(6.9)	(12.1)	(10.9)	(8.9)
North	2,982	3,271	3,795	6,045	4,783	5,521	5,630
	(7.8)	(8.7)	(9.4)	(10.6)	(8.1)	(8.1)	(7.2)
Northeast	5,075	4,456	5,236	8,583	20,171	21,944	26,229
	(13.2)	(11.8)	(12.9)	(15.1)	(34.1)	(32.2)	(33.5)
South	2,816	2,723	3,008	4,340	4,733	5,781	6,377
	(7.3)	(7.2)	(7.4)	(7.6)	(7.9)	(8.5)	(8.2)
BMR[3]	21,050	21,133	21,890	28,619	16,692	20,291	23,832
	(54.7)	(56.0)	(53.9)	(50.2)	(28.19)	(29.7)	(30.5)
Total (no.)	38,476	37,766	40,591	57,033	59,211	68,243	78,217
Total (%)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

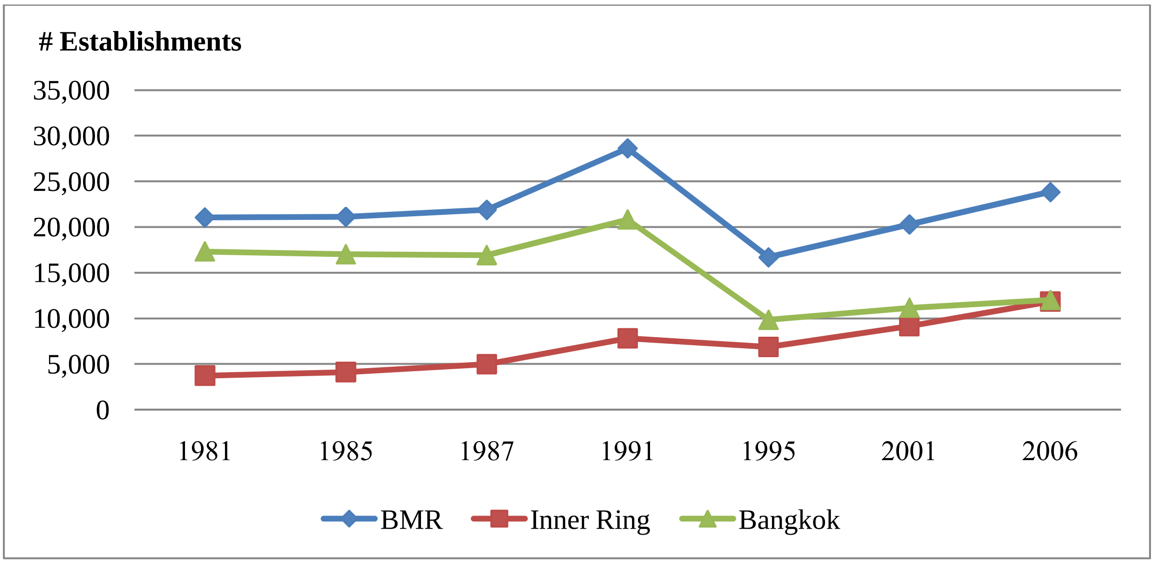
Notes: (1) Inner Ring = Nonthaburi, Nakhon Pathom, Pathum Thani, Samut Prakan, and Samut Sakhon; (2) Outer Ring = Phra Nakhon Si Ayutthaya, Angthong, Saraburi, Nakhon Nayok, Chachoengsao, Chon Buri, Suphan Buri, Rachaburi, Kanchanaburi, and Samut Songkhram; (3) the Bangkok Metropolitan Region (BMR) = Bangkok + Inner Ring; (4) the numbers in parenthesis represent percentage share; (5) based on the DIW's definition, manufacturing establishments = workshops that use machines with at least five horsepower engines or have at least seven workers; and (6) the numbers of establishments shown in this table do not account for the number of rice mills.
Sources: (1) Division of Factory Control, Department of Industrial Works (DIW) for the years 1981, 1985, 1987, and 1991 (Cited in Poapongsakorn (1995)); (2) Factory Information Center, Department of Industrial Works for the years 1995, 2001, and 2006.

Figure 3.1: Changes in the number of manufacturing establishments by regions, 1981-2006



Source: Author, based on the source identified for Table 3.4

Figure 3.2: Changes in the number of manufacturing establishments in the BMR, 1981-2006



Note: BMR = Bangkok + Inner Ring
Source: Author, based on the source identified for Table 3.4

As can be seen from Figure 3.2, when the number and share of establishments in Bangkok decreased between 1981 and 1987, the number and share of establishments in the

Inner Ring increased in the same period. Thus, when industrial relocation from Bangkok took place during the 1980s, the Inner Ring was the area that absorbed a number of establishments that moved from Bangkok. The process of industrial relocation from Bangkok to the Inner Ring can be explained by some factors. First, in 1987, the Board of Investment (BOI) ceased to grant investment privileges to industrial projects located in Bangkok (except for large export firms with at least 200 employees) in order to reduce congestion problems. This reduced incentives for new projects, especially small and medium ones, to be established in Bangkok. Second, the Bangkok General Plan[38] prohibited industries in Bangkok from being located outside industrial estates or along the main roads. However, land price in industrial estates in Bangkok was 100-300% higher than in neighboring provinces. Investors were left with no choice but to find cheaper lands in nearby areas. Finally, as manufacturing establishments in Bangkok started to grow, they needed more land to enlarge their factory sites. In Bangkok, this choice was very difficult because manufacturers could not obtain a permit to locate their enlarged factories near residential areas. Consequently, many new industrial projects and existing establishments that wanted to enlarge their size had to find other locations. Thus, they moved to the Inner Ring area where they could reduce land costs and, at the same time, still be close to Bangkok in order to benefit from its large market demand and well-developed infrastructures (Poapongsakorn, 1995).

Between 1987 and 1991, there was a large increase in industrial establishments in Thailand (from 40,591 in 1987 to 57,033 in 1991). A rapid expansion of the Thai economy with average annual GDP growth of 10% during the period 1986-1991 brought about a number of new establishments (Buurman and Rietveld, 1999). In this period, all regions

[38] The Bangkok General Plan (BGP) is a five-year plan starting in 1977. The plan is implemented by the Bangkok Metropolitan Administration as the social, economic, infrastructural, and environmental development strategies for Bangkok. According to the Third Bangkok General Plan (1987-1991), new establishments are not allowed to be located outside the industrial estates due to the environmental problems (see BMA 1987).

enjoyed an increase in the number of establishments and all regions except Bangkok enjoyed an increase in the share of establishments (in Bangkok, the share of establishments decreased, despite an increase in the number of establishments from 16,818 in 1987 to 20,817 in 1991). The number and share of establishments had still continued to grow in the Inner Ring area. The Outer Ring area, which consists of provinces near the Inner Ring, increased its importance in this period. The Thai government's Eastern Seaboard (ESB) scheme[39], which aimed to establish a new industrial center in the southeastern provinces of Bangkok, provided many incentives in terms of well-developed infrastructure (e.g., seaport, roads, railways, and telecommunication systems), tax exemption or reduction, and investment privileges for industrial projects located in Chonburi, Chachoengsao, and Rayong provinces, especially for heavy industries as well as export-oriented industries. During the 1980s, road and railway networks were rapidly expanded in the ESB area.[40] These transport networks facilitate physical connections among ESB provinces as well as between ESB provinces and the BMR. Two seaports – Laem Chabang and Map Ta Phut – were constructed respectively in Chonburi and Rayong provinces to supplement Khong Toey port (the only import-export port at that time) in Bangkok; Khong Toey port was no longer sufficient to support the large and increased flows of import and export products (Buurman and Rietveld, 1999). Laem Chabang and Map Ta Phut soon became the nation's main seaports for the import and export of goods.[41] As most of ESB was part of the Inner Ring and Outer Ring areas, it is not surprising

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[39] The Eastern Seaboard (ESB) scheme is a large-scale infrastructure development project of the Thai government. The scheme was initiated in 1982 as one of the priority issues in the Fifth National Economic and Social Development Plan (1982-1996). The ESB aims to promote industrial development in the provinces along the eastern coast including Chon Buri, Chachoengsao, and Rayong. The main elements of the ESB scheme include: (1) the development of industrial estates; (2) the construction of deep seaports (Laem Chabang and Map Ta Phut); and (3) the development of necessary infrastructure such as roads, railways and telecommunication systems (www.nesdb.go.th).

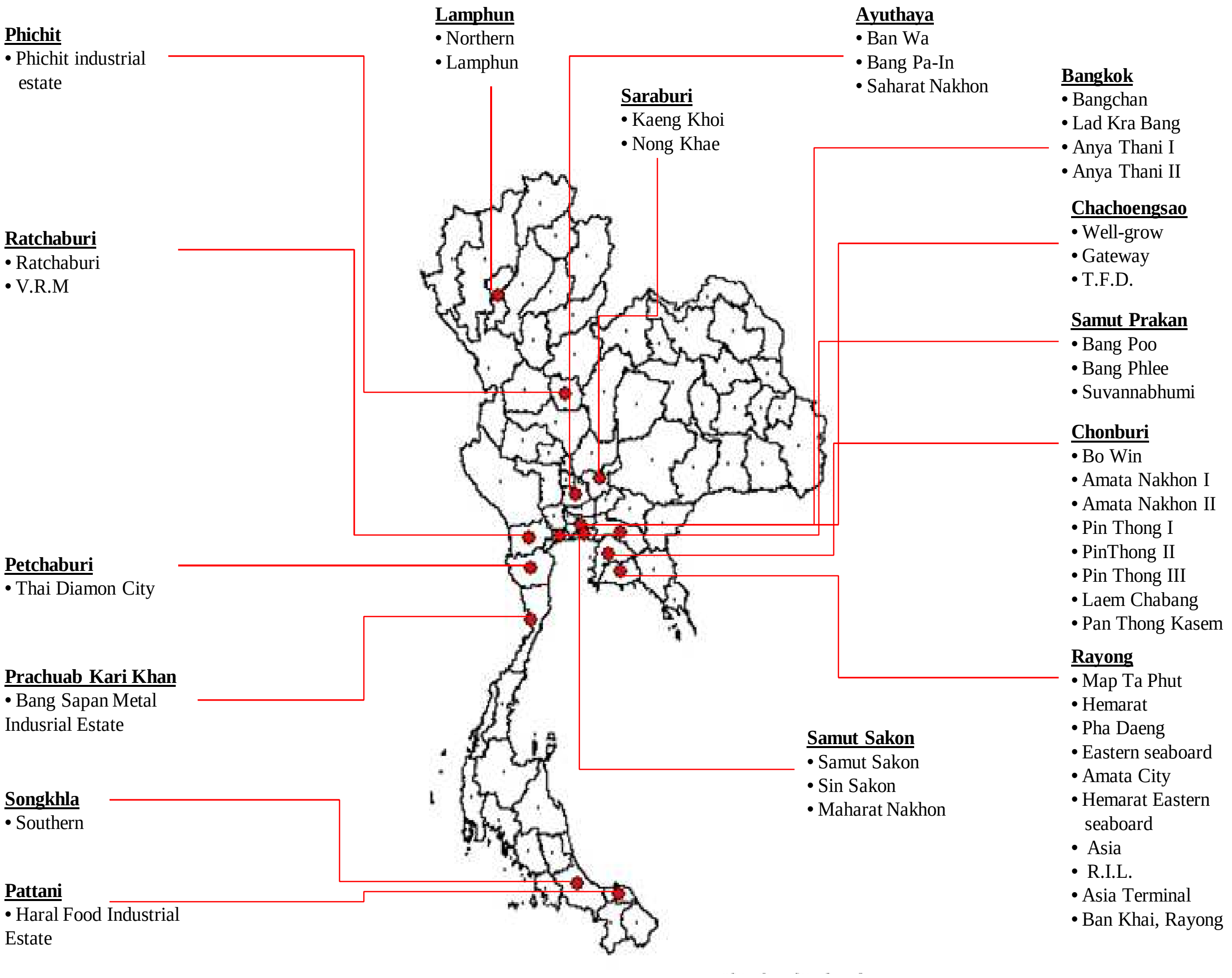
[40] In 1994, the density of roads in ESB provinces was about 0.14 km per km^2 which is higher than the national average of 0.10 km per km^2 (Buurman and Rietveld 1999, p.51).

[41] For a map of the Eastern Seaboard area see http://www.boi.go.th/Eastern%20Seaboard.pdf (access: March 20th, 2011.

why the number of establishments increased significantly in these two areas during the 1987-1991. At the same time, the number of new investment projects also increased considerably in the northeastern and western provinces of Bangkok (e.g., Ayutthaya, Angthong, Saraburi, Rachaburi, Suphan Buri, Kanchanaburi and Samut Songkhram). All of these provinces, which are situated in the Outer Ring area, significantly increased their number and share of establishments during this period (Poapongsakorn 1995).

Along with the ESB scheme, many industrial estates have been constructed in the Outer Ring provinces including Ayutthaya, Chon Buri, Chachoengsao, Rayong, Saraburi and Ratchaburi from the early 1990s onward. As can be seen from Figure 3.3, many industrial estate projects are concentrated in these provinces. Those industrial estates absorb a number of new industrial projects that have taken place as a result of industrial relocation from Bangkok (Lecler, 2002). Moreover, by investing in the Outer Ring provinces, investors can also enjoy many kinds of incentives provided under the BOI's zone-based investment incentive schemes. For example, in Zone 2 and Zone 3 (which together cover the whole Outer Ring area, see Table 3.5 for details), investors are offered incentives in terms of exemption of import duty on imported machineries (or 50% reduction if investing outside industrial estate areas). A corporate income tax exemption is also provided for 7 years for the industrial investment projects in Zone 2 (provided that investment is in industrial estate areas) or for 8 years for projects in Zone 3 (see other incentives Table 3.5). Together with the ESB scheme, BOI incentives have made the Outer Ring provinces attractive for those investors who wanted to avoid congestion in the BMR and invest in the provinces nearby.

Figure 3.3: Industrial estates in Thailand



Source: Industrial Estate Authority of Thailand (IEAT) (March 20, 2011)

Table 3.5: BOI's zone-based investment incentives

Granting tax & Duty privileges	Zone 1		Zone 2		Zone 3(1)		Zone 3(2)	
	IE	Outside IE	IE[(a)]	Outside IE	IE	Outside IE	IE	Outside IE
1. Import duty on machinery	50% red.	50% red.	Exemption	50% red.	Exemption	Exemption	Exemption	Exemption
2. Corporate income tax Exemption	3 years	-	7 years*	3 years	8 years [(b)]	8 years	8 years	8 years
3. Import duty on raw or essential materials used in manufacturing of export products	Exception for 1 year	Exception for 1 year	Exception for 1 year	Exception for 1 year	Exception for 5 years	Exception for 5 years	Exception for 5 years	Exception for 5 years
4. Double deduction from transportation, electricity and water costs	-	-	-	-	√	-	√	√
5. 50 percent reduction of corporate income tax for 5 years	-	-	-	-	√	-	√	√
6. Deduct the project's infrastructure installation or construction cost	-	-	-	-	√	√	√	√
7. Duty on raw or essential materials used in the manufacturing of domestic sales	-	-	-	-	[(c)]	-	[(d)]	-

Note: (1) ***Zone 1*** = BMR (i.e., Bangkok, Samut Prakan, Samut Sakhon, Nonthanburi, Pathum Thani, Nakhon Pathom); ***Zone 2*** = Ang Thong, Ayutthaya, Chachoengsao, Chon Buri, Kanchanaburi, Nakhon Nayok, Phuket, Ratchaburi, Rayong, Samut Songkhram, Saraburi, and Suphanburi; ***Zone 3(1)*** = 36 provinces not in Zone 1 and Zone 2 and Laem Chabang IE and Industrial Estate/Promoted Industrial Zone in Rayong; ***Zone 3(2)*** = 22 provinces not in Zone 1, Zone 2 and Zone 3(1). (2) [(a)] = Excluding Laem Chabang IE and Industrial Estates/Promoted Industrial Zone in Rayong ; [(b)] = including Laem Chabang Industrial Estate/Promoted Industrial Zone in Rayong; [(c)] = 75% reduction for 5 years*, with year-by-year approval (excluding Laem Chabang Industrial Estate and Industrial Estate/ Promoted Industrial Zone in Rayong); [(d)] = 75% reduction for 5 years*, with year-by-year approval. (3) (√) = shall be granted privileges; (–) = shall not be granted privileges; and * = for all applications submitted during January 1, 2005 to December 31, 2009. *Source*: BOI (March 21, 2011).

Does the spatial distribution pattern of particular industrial sectors exhibit a similar trend to that of the overall manufacturing industry? In the previous subsection, I have shown that the level of change in Gini coefficients varies across industries. This means that the degree of spatial adjustment (i.e., spatial deconcentration) for each sector is not at the same level. Now, in order to elaborate on this finding, we need to see how each industry is geographically distributed. To save space and discuss the data in a simple fashion, I show the regional distribution of 2-digit manufacturing industries based on industrial category.

Table 3.6 and Figure 3.4 present the regional distribution of manufacturing industries by industrial category. The first thing to note is that Bangkok lost manufacturing establishments in every industry category during the period 1996-2006. The percentage loss ranges from 20.3% in the resource-based sector to 46.2% in the machinery sector. In 1996, the share of manufacturing establishments in Bangkok was very high especially for the labor-intensive, MCP, and machinery sectors; Bangkok had establishment shares of 64.2, 50.1, and 47.2, respectively for these sectors. The only exception is the resource-based sector, in which Bangkok accounted only for 19.9 percent share of establishments; however, in 2006 the share of establishments in Bangkok dropped significantly in every industry category. Bangkok's share fell to less than 20% in every category. The losses in the number and share of establishments in every sector over the last decade suggest that Bangkok has been losing its importance as the traditional industrial center of the country in both absolute and relative terms.

The Inner Ring and Outer Ring areas exhibit similar pattern of industrial distribution: the number of establishments increased in every industrial category during the period 1996-2006, but the share of establishments decreased in all categories except in machinery. For the Inner Ring area, the increase in the share of establishments is very high in MCP sector (which increased 86.2%). The Outer Ring area registers a large increase in the number of establishments in resource-based and MCP sectors (which increased 310.6% and 212.4%, respectively).

The Centre, the North, the Northeast, and the South also show similar patterns of industrial distribution: the number and share of establishments increased in every industry category. The increase in the number of establishments of these four regions is particularly high in labor-intensive and MCP industries. For example, during the 1996-2006 period the Centre increased the number of labor-intensive and MCP establishments by about 7 and 5.5 times, respectively, while the Northeast increased the number of establishments in these two industries to about 14 and 13 times their 1996 level.

Although the four peripheral regions enjoyed a large increase in the number and share of establishments in all industrial categories, which would cause more spatial dispersion and a more equal regional distribution in these industries, the rate of dispersion is still different across industry categories. First, for the resource-based group, the spatial adjustment took place fairly quickly such that Bangkok, Inner Ring, and Outer Ring areas saw their collective establishment share drop from more than 50% in 1996 to 30.1% in 2006. Conversely, four peripheral regions collectively increased their share from about 48% to about 70% during the same period. As shown by the Gini coefficients, industries belonging to this category have moved toward more equal spatial distribution. This is confirmed by the fact the peripheral regions – which altogether account for 88.8% of the country's area – received a higher share of establishments (about 70%) in 2006.

Second, the labor-intensive sector exhibited a trend similar to the resource-based sector. In 1996, establishments in this industrial category were highly concentrated in Bangkok, Inner Ring, and Outer Ring areas, accounting for more than 80% of establishments

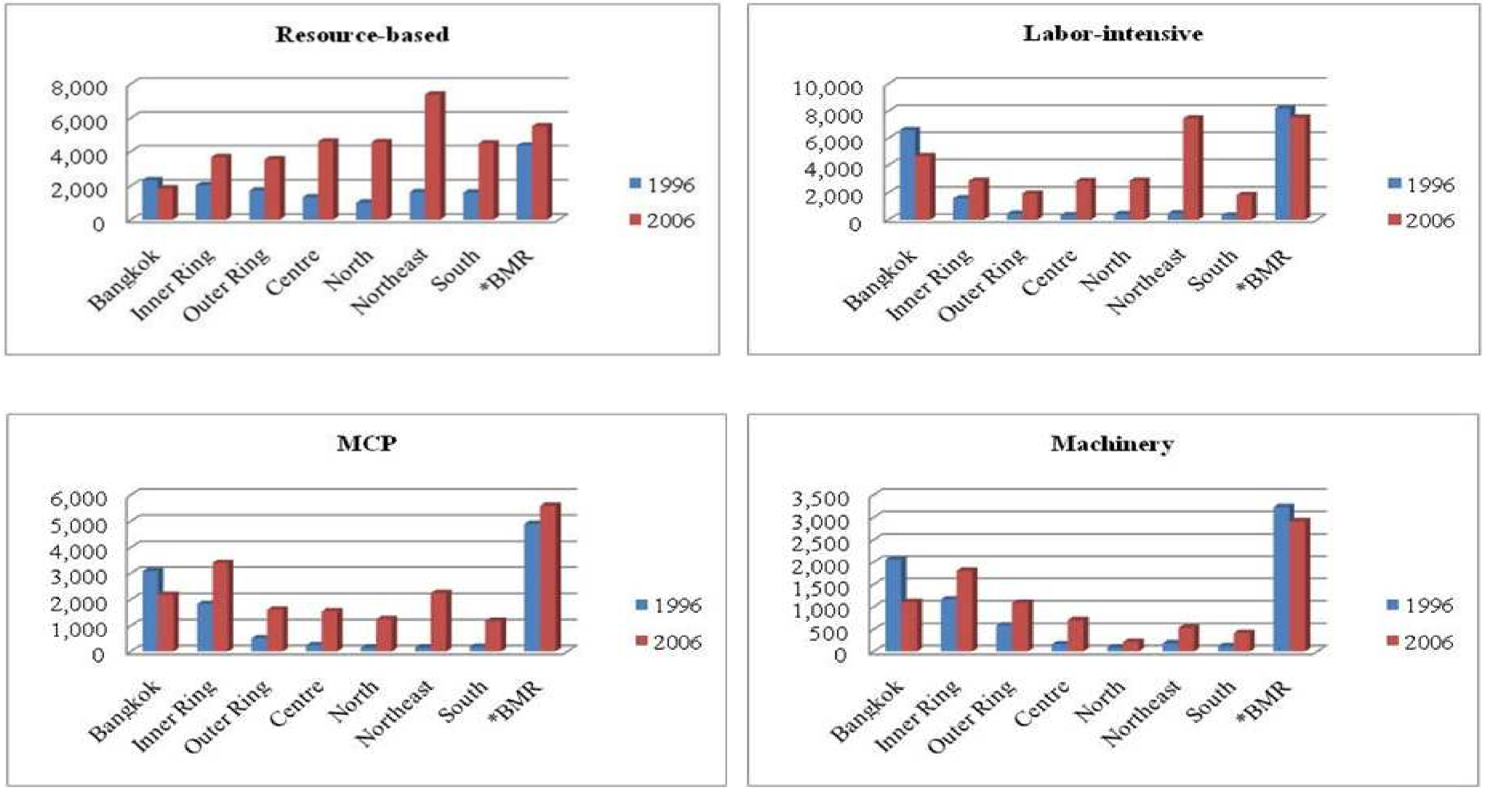
(64.2%, 15.4%, and 4.6% for Bangkok, Inner Ring, and Outer Ring, respectively). In 2006, however, the share dropped to only 38.7%. Again, four peripheral regions which had contained a minor portion of the establishment share in 1996 (15.8%) increased their share to about four times that level to 61.3% in 2006. The Northeast – the country's least developed region – significantly increased the number of establishments and accounted for about one-third of establishments in the labor-intensive sector in 2006.

Table 3.6: Regional distribution of manufacturing industries by industry category, 1996-2006

	Resource-based			Labor-intensive			MCP			Machinery		
	1996	**2006**	**Change**	**1996**	**2006**	**Change**	**1996**	**2006**	**Change**	**1996**	**2006**	**Change**
Bangkok	2,330	1,857	-473	6,613	4,674	-1,939	3,075	2,179	-896	2,061	1,108	-953
(%)	(19.9)	(6.2)	(-20.3)	(64.2)	(19.1)	(-29.3)	(50.1)	(16.2)	(-29.1)	(47.2)	(18.8)	(-46.2)
Inner Ring	2,035	3,668	1,633	1,589	2,857	1,268	1,829	3,406	1,577	1,171	1,805	634
(%)	(17.4)	(12.2)	(80.3)	(15.4)	(11.7)	(79.8)	(29.8)	(25.4)	(86.2)	(26.8)	(30.6)	(54.1)
Outer Ring	1,722	3,546	1,824	471	1,934	1,463	516	1,612	1,096	587	1,093	506
(%)	(14.7)	(11.8)	(105.9)	(4.6)	(7.9)	(310.6)	(8.4)	(12.0)	(212.4)	(13.4)	(18.5)	(86.2)
Centre	1,338	4,613	3,275	357	2,834	2,477	238	1,550	1,312	158	708	550
(%)	(11.5)	(15.3)	(244.8)	(3.5)	(11.6)	(693.8)	(3.9)	(11.6)	(551.3)	(3.6)	(12.0)	(348.1)
North	1,019	4,581	3,562	447	2,870	2,423	149	1,251	1,102	90	215	125
(%)	(8.7)	(15.2)	(349.6)	(4.3)	(11.7)	(542.1)	(2.4)	(9.3)	(739.6)	(2.1)	(3.7)	(138.9)
Northeast	1,634	7,381	5,747	490	7,450	6,960	151	2,244	2,093	185	538	353
(%)	(13.9)	(24.5)	(179.9)	(4.8)	(30.5)	(1420.4)	(2.5)	(16.7)	(1386.1)	(4.2)	(9.1)	(190.8)
South	1,610	4,506	2,896	332	1,842	1,510	176	1,182	1,006	116	427	311
(%)	(13.8)	(14.9)	(351.7)	(3.2)	(7.5)	(454.8)	(2.9)	(8.8)	(571.6)	(2.7)	(7.2)	(268.1)
BMR	4,365	5,525	1,160	8,202	7,531	-671	4,904	5,585	618	3,232	2,913	-319
(%)	(37.3)	(18.3)	(6.3)	(79.6)	(30.8)	(-4.7)	(79.9)	(41.6)	(9.3)	(74.0)	(49.4)	(-20.9)
Total	11,688	30,152	18,464	10,299	24,461	14,162	6,134	13,424	7,290	4,368	5,894	1,526
Total (%)	(100)	(100)	(157.97)	(100)	(100)	(137.51)	(100)	(100)	(118.85)	(100)	(100)	(34.94)

Note: BMR = Bangkok + Inner Ring.
Source: Author's compilation from industrial census 1997 and 2007.

Figure 3.4: Regional distribution of manufacturing establishments by industrial categories and years



Source: Author, based on industrial censuses 1997 and 2007

Third, the MCP industry category, although it shows a trend toward spatial deconcentration, is not as dispersed as the previous two industrial categories. Although the establishment shares of Bangkok, Inner Ring and Outer Ring areas together have dropped from about 88% in 1996, more than 50% of establishments were still located in these areas in 2006. At the same time, all four peripheral regions increased both the number and share of MCP establishments. However, their share of establishments was still less than those three industrialized regions in 2006. This is consistent with the previous finding that the Gini coefficient dropped more rapidly in the resource-based and labor-intensive sectors than in the MCP sector.

Finally, for the machinery industry, the trend toward spatial dispersion and deconcentration is slower than the three other industries. Bangkok, which contained about 47% of establishments in this sector in 1996, had its share reduced to about 19% in 2006. However, as the reduction of Bangkok's share was partly offset by the increase in the share from the Inner Ring and Outer Ring areas, the overall reduction of the establishment share of these three areas was not large. Consequently, these three areas still retained about 68% of the establishments in 2006. Although each of four peripheral regions had increased the number and share of establishments, such increases did not happen rapidly as compared to the three other industrial categories. Therefore, spatial concentration of the machinery industries was still at a relatively high level at least until 2006.

3.4 Conclusion

This chapter has shown that Thai manufacturing industries have adjusted their geographical distribution over time. Before the mid-1980s, manufacturing industries were highly concentrated in Bangkok – the country's largest urbanized area. Urban agglomeration advantages in terms of large market size, availabilities of labor and input suppliers, a well-developed infrastructure, and connection to import and export markets are said to reinforce concentration in Bangkok (Kittiprapas and McCann 1999). However, as agglomeration proceeded, congestion became a cause of concern. Consequently, after 1985 manufacturing establishments started to relocate or were newly established in other areas. They first moved to other provinces in the BMR (i.e., Inner Ring provinces), and then moved further to provinces in the Outer Ring area. This is because these areas have some advantages in terms of proximity to Bangkok, well-developed infrastructures, and government-provided incentives. Large-scale and nation-wide industrial decentralization have only taken place in the period since the mid-1990s, as the number and share of establishments increased at a higher rate in peripheral regions than in Bangkok and the Inner Ring and Outer Ring areas.

Nevertheless, there are some variations in the dynamics of geographic concentration among manufacturing sectors. Resource-based and labor-intensive industries registered a faster rate of dispersion and moved toward equal regional distribution more quickly, as compared to the MCP and machinery sectors. This finding is consistent with some previous studies. For example, Brulhart (1998) and Haaland et al. (1999) show that, for the European countries, labor-intensive and resource-based industries are more dispersed across space than the average, while knowledge-based or high-tech sectors observe higher concentration than the European average. He (2009) uses the Gini index to examine the geographic concentration of manufacturing industries in China from 1980 to 2004. He finds that, despite some differences across industries and time period, the most concentrated industries were capital-intensive and export-oriented industries (chemical fiber, petroleum refining, telecommunication and electronic equipments), while the least concentrated industries over time were resource-based and domestic market-oriented industries (food processing, beverages, tobacco, timber, and mineral products). Kuncoro (2009) examines geographic concentration of manufacturing industries in Java, Indonesia and finds that the overall concentration increased during the period from 1990 to 2003. According to him, the machinery industry was not only more concentrated than other industries but also increased the degree of concentration over time; on the other hand, such industries as food, beverage, and tobacco, textiles, garments, leather, and footwear, and wood and wood products were among the least concentrated industries.

The pattern of spatial distribution of Thai manufacturing industries is rather consistent with Fujita's (2007) argument about the *agglomeration* (or *centripetal*) and *dispersion* (or *centrifugal*) *forces* (see Chapter 2, pp.21-24). During the 1980s, in which transport and trade costs were still very high and Bangkok and other provinces in the BMR were still very attractive due to some agglomeration advantages such as large market size (home market effects), availability of specialized input suppliers, and connection to export market, manufacturing industries were motivated to establish and locate in the urbanized BMR. Once agglomeration reached its peak around the mid 1990s, congestion costs outweighed agglomeration benefits. Land prices and wages skyrocketed. Consequently, manufacturing activities, especially those industries that are sensitive to labor costs, moved out or started up in other locations. At the same time, continuous improvement of infrastructures and transport networks since the first national economic development plan (1961-1965) onward reduced the need for firms to locate in the market center because products can be cheaply supplied from distant locations. However, this deconcentration process is likely to be slower for the MCP and machinery industries than for resource-based and labor-intensive industries; economies of scale and increasing returns make the former less sensitive to spatial adjustment, as compared to the latter. Fujita (2007) argues that knowledge-based and technology-intensive firms tend to concentrate in large agglomeration areas where they can make use of highly skilled labor and information spillover available at these locations. The question as to whether or not such factors as economies of scale and knowledge/information spillover affect the location of manufacturing establishments is tested in Chapter 4.

Chapter 4

Spatial Clustering in Thai Manufacturing Industries

4.1 Introduction

In the previous chapter, we have seen that the degree of spatial concentration in Thai manufacturing industries varies from industry to industry. We also have observed that in every industry, the degree of concentration has declined over time, but the extent of decline varies across industries. However, what we have learned so far is just overall information about the level of, and the change in, industrial concentration. We have not yet discovered *where* or *in what location* manufacturing establishments are clustered. In particular, the change in the degree of concentration may not directly indicate the formation (or dissolution) of industrial clusters. In this chapter, I explore the spatial and sectoral agglomeration of manufacturing establishments to see where the establishments are spatially clustered. I also investigate the main factors that explain the formation of industrial clusters in order to address the first main research question of this study (i.e., *what determines spatial clustering of manufacturing establishments?*).

Until recently, there have been a small number of studies investigating the formation of industrial clusters in Thailand. Notable studies include Lecler (2002), Intarakumnerd (2005), Harryono (2006), Wonglimpiyarat (2006), Teoh et al. (2007), Tsuji et al. (2008), and Machikita, T. (2010). However, among these studies, it is only Tsuji et al. (2008) that examines the determinants of cluster formation. Despite the fact that spatial concentration of Thai manufacturing industries has been documented in many studies, few studies have systematically examined how industrial clusters have been formed or why they have existed.

This chapter, therefore, aims to examine these issues.

This chapter is structured as follows. Section 4.2 discusses the method used for identifying the spatial and sectoral agglomeration (clustering) of manufacturing establishments. Section 4.3 identifies manufacturing industrial clusters in Thailand. Section 4.4 presents the theoretical model of establishment location and the hypotheses to be tested as well as discusses variable construction and data issues. Section 4.5 presents and discusses the results of statistical analysis of establishments' locations in the industrial cluster and in emerging clusters. Finally, Section 4.6 concludes the chapter.

4.2 Method for identifying manufacturing industrial cluster

The Gini coefficient discussed in the previous chapter is a summary index for industrial concentration. It provides general information concerning the magnitude of geographical concentration of a particular industry. However, it does not tell us anything about the location at which establishments are sectorally clustered. Thus, to identify the industrial clusters, we need to have a measure that provides information on both magnitude and location of clustered establishments.

Several measures have been proposed to identify industrial clusters. Those measures differ from each other in terms of theoretical foundation and analytical method (see, for example, Czamanski and de Q. Ablas 1979; vom Hofe and Bhatta 2007; and Titze et al. 2008). Yingming (2010) argues that industrial clusters have two basic characteristics – spatial links and functional links (or input-output links). Spatial links can be measured using geographical concentration indices, while functional links are normally measured using regional flows of inputs and outputs. To identify industrial clusters, it is necessary to take both characteristics into account (Ibid.). However, in this study, I only focus on spatial-link aspect of industrial clusters, because the data on input-output flows are not available at the regional level in the case of Thailand.

The spatial-link aspect of industrial clustering can be captured by several measures. One measure that is frequently used in the literature on industrial agglomeration is the so-called *Location Quotient* (*LQ*) which measures the presence of a particular industry in a particular region relative to its presence in the whole economy.[42] In many studies (e.g., Madsen et al. 2003; Fingleton et al. 2004, 2005, 2007, and 2008; Maggioni and Riggi 2008), *LQ* is used together with other measures to identify industrial clusters.

Despite the fact that *LQ* has been widely used, it has some limitations in serving as a measure of industrial clustering. The most critical shortcoming of *LQ* is that it only tells us whether a region has a higher or lower share of a particular industry than the national share but does not provide us with any information about the absolute size of the industry in that region (Fingleton 2008, p.83). Consequently, it is possible to obtain a high *LQ* value despite a very small number of establishments.[43] With this limitation, it is therefore necessary to find an alternative measure which accounts for both relative presence and absolute size of the

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[42] The *Location Quotient* of industry *j* in region *r* (LQ_{jr}) is defined as:, where E_{jr} denotes the number of establishments (or employment, outputs, value added) in sector *j* and region *r*; E_r the number of all establishments (all jobs, outputs, value added) in region *r*; E_j the number of all establishments (all jobs, outputs, value added) in sector *j*; and E_n the number of establishments (employment, outputs, value added) in the whole nation. The interpretation of LQ_{jr} depends on the value it takes in a particular range as follows: (1) if LQ_{jr} lies between zero and one ($0 < LQ_{jr} < 1$), then industry *j* is less prevalent in region *r* as compared to its presence in the whole economy; (2) if LQ_{jr} equals one ($LQ_{jr} = 1$), then the presence of industry *j* in region *r* is just same as its presence in the whole economy; If LQ_{jr} is greater than one ($LQ_{jr} > 1$), then industry *j* is more prevalent in region *r* as compared to its presence in the whole economy. In short, *LQ* is a method used for measuring how a region is specialized to a particular industry (see, for example, Fingleton 2007 for a discussion on this measure).

[43] For example, suppose that region *X* has only two manufacturing industrial sectors (say, sector *a* and sector *b*) and that sector *a* has 5 establishments ($Xa = 5$) and *b* has 15 establishments ($Xb = 15$) so that the total number of establishments in region *X* is 20. Suppose further that, in the country, there are 20 establishments in sector *a* and that there are 1,000 establishments all over the country. Then, the *LQ* for sector *a* in region *X* is 12.5, which means that the share of sector *a* in region *X* is 25 times as high as its share in the whole economy. Although this is a very high *LQ* value, we cannot claim much of an industrial cluster with only 5 establishments in the region.

regional industry.[44]

Following Fingleton (2007), I use the index of establishment density which is defined as:

$$PD_{jr} = \frac{P_{jr}}{A_r}$$

where P_{jr} is the number of establishments in sector j and province r, and A_r is the area of province r in square kilometers. By definition, this index captures the size (in terms of number of establishments) of industry relative to provincial area size. It tells us, for each square kilometer of province r, how many establishments in industry j are located in that area. Hence, by looking at PD_{jr}, we can easily see whether establishments in sector j are densely located in province r. However, we still need a threshold by which we can consider PD_{jr} as an indication of an industrial cluster (i.e., at what density that provincial industry can be identified as an industrial cluster). In this study, I take the level of establishment density in the Bangkok Metropolitan Region (BMR) as a threshold for identifying a particular provincial industry as a cluster. The reasons for taking the establishment density of the BMR as a threshold are both analytical and practical. For analytical reasons, because the BMR is considered by the previous studies (e.g., Kittiprapas and McCann 1999; Tsuji et al. 2008; Machikita 2010) as a large industrial cluster, taking the BMR as a threshold of industrial clustering is analytically consistent with those previous studies. For practical reasons, the BMR is still a large industrial concentration area in both absolute and relative terms. That is, the BMR still hosts a large number of manufacturing establishments (in absolute terms) and

[44] With respect to these shortcomings of the *LQ* measure, Fingleton et al. (2004) suggests a modified version of *LQ* which takes into account the relative importance of regional industry and the size of the agglomeration measured by the number of jobs. For this approach, industrial clustering is measured in accordance with the number of establishments (or jobs, outputs, value added) in the industry which exceeds the number that would be expected to be produced if "$LQ = 1$". This approach is conducted by first calculating the *LQ* (according to the standard formula (defined in footnote 1). Then element E_{jr} is replaced by $\hat{E}_{jr}$ which is the expected number of E_{jr} that would keep *LQ* equal to one. Industrial clustering, then, is measured as the difference between actual and expected values of E (or $E_{jr} - \hat{E}_{jr}$).

still has the largest share of establishments (in relative terms) for most of the industries (see Chapter 3), despite the fact that the industrial share of the BMR has declined from previous decades. Hence, any industry *j* in province *r* can be identified as an industrial cluster if its establishment density (PD_{jr}) is equal or greater to that of the BMR (i.e., if $PD_{jr} \geq PD_{j,BMR}$, then industry *j* in province *r* is an industrial cluster).

It should be noted that due to the fact that data are most complete at the provincial level, I take the province as a spatial unit to measure industrial clustering. Because of this, the possibility exists that establishments may be clustered at a larger or smaller spatial scope than the province. Thus, a measure of industrial clustering applied in this study should be considered as an approximation of clustering at the provincial level. Having recognized such limitations, I try to supplement my analysis by the use of previous studies and relevant information such as the number and density of establishments in each location, establishment size structure, and the value of outputs.

For the purpose of detailed discussion, the analysis in this chapter is based on a case study of three industries – motor vehicles (ISIC34), food products and beverages (ISIC15), and textile (ISIC17). These industries are selected for several reasons. First, some previous studies have focused on these sectors. By focusing on these sectors, it is possible to compare the results of the current study with the previous ones. Second, these sectors are selected based on the industrial categories identified in Chapter 3. One sector is selected from each category in order to see how spatial clustering differs across industrial categories.[45] Finally, these industries are among the best-performing industries in Thailand (Table 4.1).

[45] No industry from metal, chemical and paper (MCP) group is selected here because this group of industries shows a spatial distribution pattern similar to that of machinery industry group from which I have selected motor vehicles as a case study.

Table 4.1: Industrial performance by industrial category (selected indicators), 2006

Industry	Export (million baht)	Employment (persons)	wage/employee (million baht)	Value added (million baht)
ISIC15	286,729.80	802,522	0.076	245,302.10
ISIC16	3,527.10	10,541	0.284	30,744.30
ISIC17	84,096.80	409,648	0.065	66,658.00
ISIC18	90,197.30	449,011	0.069	60,608.40
ISIC19	32,469.10	132,387	0.097	27,735.40
ISIC20	19,419.10	199,201	0.039	20,659.80
ISIC21	23,023.00	80,924	0.12	36,772.60
ISIC22	1,933.80	88,266	0.123	24,196.30
ISIC23	61,501.50	8,249	0.179	32,844.90
ISIC24	113,467.60	163,150	0.12	111,168.40
ISIC25	207,146.50	312,900	0.113	122,590.00
ISIC26	30,064.30	201,268	0.091	65,653.10
ISIC27	51,803.50	73,380	0.123	53,557.70
ISIC28	85,438.20	295,585	0.094	94,508.10
ISIC29	260,223.30	165,340	0.135	96,287.60
ISIC30	33,967.40	46,318	0.152	17,752.30
ISIC31	89,118.30	123,624	0.136	54,661.30
ISIC32	699,379.00	290,882	0.142	258,893.00
ISIC33	54,791.60	39,848	0.141	24,677.90
ISIC34	123,512.30	159,671	0.155	215,844.10
ISIC35	12,800.50	46,976	0.148	34,450.20
ISIC36	113,202.10	358,038	0.087	62,397.60
ISIC37	390.2	2,558	0.059	795.2

Source: Author’s compilation from industrial census 2007

4.3 Evidence of spatial clustering in Thai manufacturing industries

This section discusses spatial clustering in each selected industry. It explores how spatial clustering has changed over time and also compares the results with the data shown in Chapter 3. Based on the establishment density index and the threshold $PD_{jr} \geq PD_{j,BMR}$, it is found that, in all selected industries, the magnitude of spatial clustering of establishments in other provinces is not as large as that in the BMR. Thus, I argue that the BMR is still the only industrial cluster in Thailand.

However, I observe that currently the number of establishments that have started up or been relocated to other areas is larger than before. In food products and beverages and textile industries, establishments have begun to be agglomerated in some peripheral provinces (particularly, in the Northeast, the North, and the South). In the motor vehicle industry, I observe that the number of establishments have increased significantly in such provinces as Ayutthaya, Chon Buri, Chachoengsao, and Rayong, which are close to the BMR. With a significant increase in the number of establishments in those provinces, therefore, it can be shown that two spatial configurations exist in each of the three selected industries; one is the industrial clusters which have taken place in the BMR, another one is the emerging clusters which have taken place in the provinces that exhibit a large increase in the number of establishments. Note that the term “emerging clusters” is used here to refer to the provinces which are moving toward the formation of industrial clusters. I discuss the chosen industries case by case as follows.

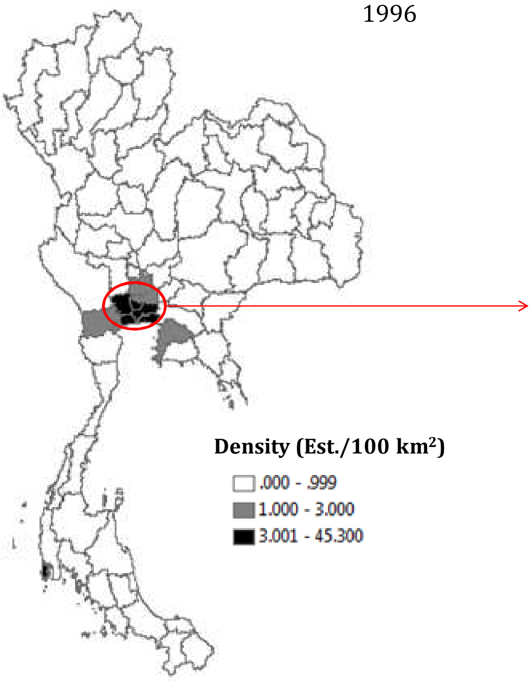
4.3.1 Spatial clustering in motor vehicle industry (ISIC34)

The special clustering of the motor vehicle industry in and around the BMR is documented by some studies (e.g., Lecler 2002; Teoh et al. 2007; Techakanont 2008; Machikita 2010). The location pattern of motor vehicle establishments is presented in Figure 4.1. As can be seen, while the number of establishments in the whole kingdom has declined from 1,501 in 1996 to 1,007 in 2006 (or 33%), establishments in the BMR have dropped more rapidly, from 1,007 to 547 (or 46%).[46] Consequently, the BMR’s motor vehicle establishment density has dropped from 11.8 establishments per 100 Km^2 in 1996 to 7.6 establishments per 100 Km^2 in 2006, and its share has dropped from 67.1% to 54%.

[46] Though the number of establishments has declined rapidly, this industry still registers better performance in some respects. For example, gross production value has increased (in real terms) by around 40%, from 466,263.6 million baht in 1996 to 653,555.7 million baht in 2006, while employment has increased by around 48% from 107,965 jobs to 159,671 jobs in the same period (Author’s calculation from industrial censuses of 1997 and 2007).

Figure 4.1: Mapping of spatial clustering in motor vehicle industry

1996

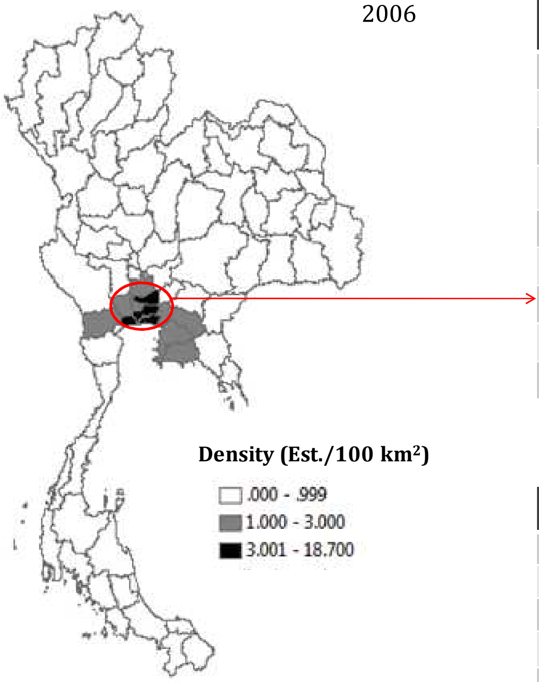


Province	# Establishments	Density
Bangkok	711	45.3
Samut Prakan	93	9.3
Samut Sakon	46	5.3
Nakhon Pathom	88	4.1
Patum Thani	42	2.8
Nonthaburi	27	4.3
# BMR Total (%)	**1,007(67.1)**	
Whole Kingdom	**1,501(100)**	
BMR Density		**11.8**

Other provinces

Province	# Establishments	Density
Chon Buri	64	1.4
Ayutthaya	26	1.0
Chachoengsao	24	0.4
Rayong	11	0.3
Total	**125(8.3)**	
Whole Kingdom	**1,501(100)**	

2006



Province	# Establishments	Density
Bangkok	172	11.0
Samut Prakan	188	18.7
Samut Sakon	74	8.5
Nakhon Pathom	47	2.2
Patum Thani	57	4.0
Nonthaburi	9	1.4
# BMR Total (%)	**547(54.3)**	
Whole Kingdom	**1,007(100)**	
BMR Density		**7.6**

Other provinces

Province	# Establishments	Density
Chon Buri	124	3.0
Ayutthaya	44	2.0
Chachoengsao	44	1.0
Rayong	40	1.1
Total	**252(25.0)**	
Whole Kingdom	**1,007(100)**	

Source: Author

The decline in the number and density of motor vehicle establishments in the BMR can be attributed to the reduction of establishments in the city of Bangkok, the industrial center of the BMR. In fact, there is some evidence suggesting that several manufacturing activities have started to move out from Bangkok since the late 1980s (Paopongsakorn 1995; Kittiprapas and McCann 1999). In the case of the motor vehicle industry, establishments have not gone far away from Bangkok. Instead, they have moved to the other areas in the outer-ring of the BMR[47] (i.e. Samut Prakan and Samut Sakon) or to nearby provinces (i.e. Ayutthaya, Chon Buri, Chachoengsao, and Rayong). The relocation of many establishments from the city of Bangkok to other nearby areas is attributable to both economic factors as well as to government-induced incentives (Poapongsakorn 1995). First, by the late 1980s and the early 1990s, there was some evidence suggesting that congestion costs in Bangkok began to outweigh its agglomeration benefits. For example, land price in industrial estates (IEs) in Bangkok city was 100%-300% higher than that in IEs of neighboring provinces (Paopongsakorn 1995). Wages in Bangkok had increased by an average of 9% per year during 1990-1994 (Reinhart 2000, cited in Lecler 2002). Moreover, infrastructural bottlenecks, especially the congestion at the main roads and Khlong Toei port (the only main port in Bangkok), had also increased the costs of locating plants in Bangkok city (Techakanont 2008). As a result, several vehicle assemblers and part producers started to move to Bangkok's neighboring areas, where the congestion costs were still minimal.

Second, by the late 1980s, government policies aiming to disperse industries away from Bangkok city had been fully implemented. Government policies that are often cited as important factors for the formation of a motor vehicle cluster in and around the BMR include the Eastern Seaboard (ESB) scheme, BOI investment incentives, and the industrial estate

[47] I use the term outer-ring of the BMR to refer to other provinces in the BMR, apart from Bangkok and Nonthaburi, including Samut Prakan, Samut Sakon, Pathum Thani, and Nakhon Pathom. This is different from the outer-ring region discussed in Chapter 3, which refers to provinces contiguous to the BMR.

policy (Lecler 2002; Techakanont 2008). During the late 1980s and the 1990s, many new industrial estates were developed along the highway and road networks connecting Bangkok city with its neighboring provinces. The location of IEs along the highway and road networks provides establishments with greater benefits. First, as IEs are not too far from Bangkok, it is still easy for establishments to contact with their headquarters or offices in Bangkok and to utilize business services in Bangkok. Second, by being located in those IEs, establishments can avoid congestion costs in Bangkok (Lecler 2002).

Establishments located in IEs also enjoy various benefits provided by the BOI's zone-based incentives. The type and amount of benefits that they receive depends on the zone where they are located. For example, in zone-1 (the BMR), incentives are given in terms of a complete corporate income tax exemption for three years, and 50% reduction of duties on capital goods. In zone-2 (Ayutthaya, Chon Buri, Chachoeng, Ratchaburi, and Saraburi), corporate income tax is exempted for seven years, plus there is a 50% reduction of duties on capital goods. In zone-3 (other areas apart from zone-1 and zone-2), establishments benefit from corporate income tax exemption for eight years and a 50% reduction for a further five years, plus 100% exemption from duties on capital goods.[48] Although zone-3 provides establishments with greater incentives, motor vehicle establishments are only located in zone-1 and zone-2 where they can utilize the modern infrastructure and more developed business services as well as easily establish production networks with other establishments in these zones (Techakanont 2008).

The ESB scheme (see footnote 19 in Chapter 3 for details) which started in the mid-1980s and completed by the mid-1990s also provided vehicle manufacturers with modern infrastructures in terms of transportation and communication networks and deep sea ports

[48] See www.ieat.go.th

(i.e., Laem Chabang in Chonburi province and Mab Ta Phut in Rayong province). As shown in Figure 4.1, the number of motor vehicle establishments increased significantly during the period 1996-2006 in Chon Buri, Chachoengsao, and Rayong – provinces that the ESB scheme covered.

When we look at the year of establishment and the location of major automobile manufacturers and their part suppliers (Table 4.2 and 4.3), the location pattern becomes clear. During the 1970s and 1980s, the BMR (i.e. Bangkok, Samut Prakan, and Pathum Thani) was the main cluster of automobile establishments. But in the 1990s, the cluster expanded to Chon Buri, Chachoengsao, Rayong, and Ayutthaya, thanks to the ESB scheme and IEs established in these provinces (Lecler 2002).

Table 4.2: Year of establishment and location of major automobile assemblers

No.	Assemblers	Year (est.)	Location
1	Nisson (Siam Motors)	1962	Samut Prakan
2	Toyota	1964	Samut Prakan
3	Hino	1966	Samut Prakan
4	Mitsubishi	1966	Bangkok
5	Isuzu	1966	Samut Prakan
6	Mazda	1975	Bangkok
7	Nisson (Siam Nisson Auto)	1977	Samut Prakan
8	Nisson Diesel	1987	Pathum Thani
9	Mitsubishi	1992	Bangkok
10	Honda	1993	Chonburi
11	Toyota	1996	Chachoengsao
12	Honda	1996	Ayutthay
13	Isuzu		Chachoengsao
14	Auto Alliace Thailand (Mazda/Ford)	1998	Rayong
15	General Motors	1998 (2000)	Rayong
16	BMW	2000	Rayong

Source: Lecler (2002, p.808)

Table 4.3: Location of major automobile part makers by year of establishment

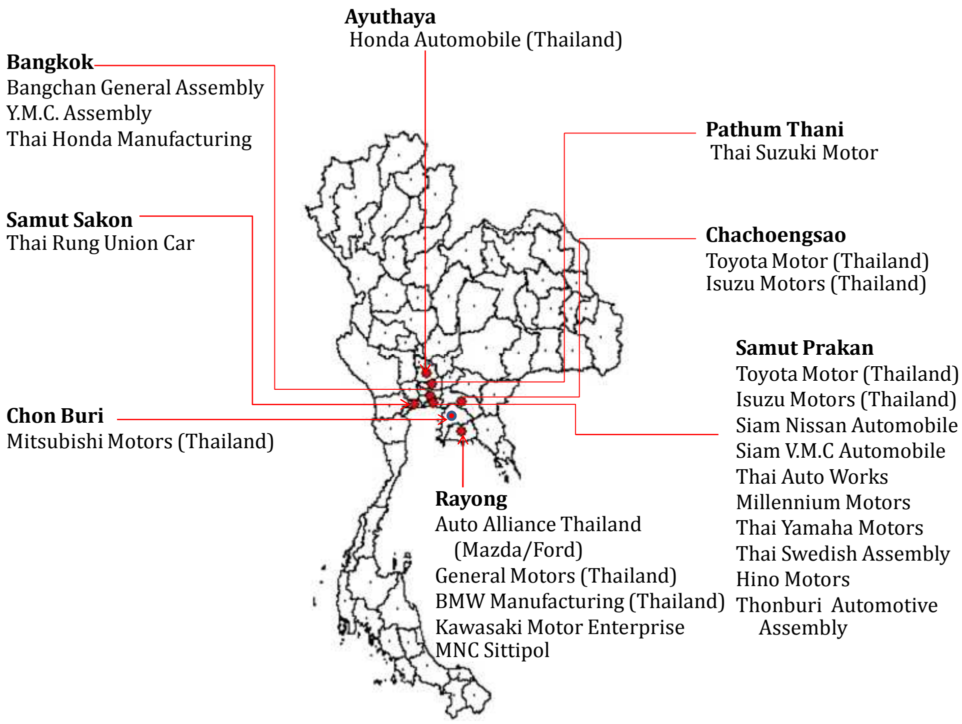
Location	1969	1970-79	1980-89	1990-95	1996-98	Total
Bangkok	3	6	6	9	8	32
Samut Prakan	4	7	11	4	4	30
Pathum Thani	1	1	8	4	1	15
Chonburi	-	1	1	12	6	20
Chachoengsao	-	-	3	3	2	8
Rayong	-	-	-	4	16	20
Ayutthay	-	-	-	5	2	7
Others	-	-	2	3	6	11
Total	8	15	31	44	45	143

Source: Lecler (2002, p.808)

In sum, by 1996 the BMR was still the main cluster of the motor vehicle industry. However, the industrial relocation and spatial adjustment processes which had been taking place since the late 1980s seems to have changed the degree of spatial concentration of this industry. Motor vehicles establishments have started to relocate or newly establish in provinces contiguous with the BMR, thanks to higher congestion costs in the city of Bangkok and such government industrial location policies as the ESB scheme and IEs development. Recently, motor vehicle establishments have moved to such provinces as Chon Buri, Chachoengsao, Rayong, and Ayutthaya, which have the advantages of being close to Bangkok and well-developed infrastructures. Figure 4.2 and Figure 4.3 give a rough picture of the current motor vehicle cluster in Thailand. These two figures show that automobile assemblers and their parts suppliers are agglomerated in the BMR and its four neighboring provinces (Chon Buri, Chachoengsao, Rayong, and Ayutthaya).

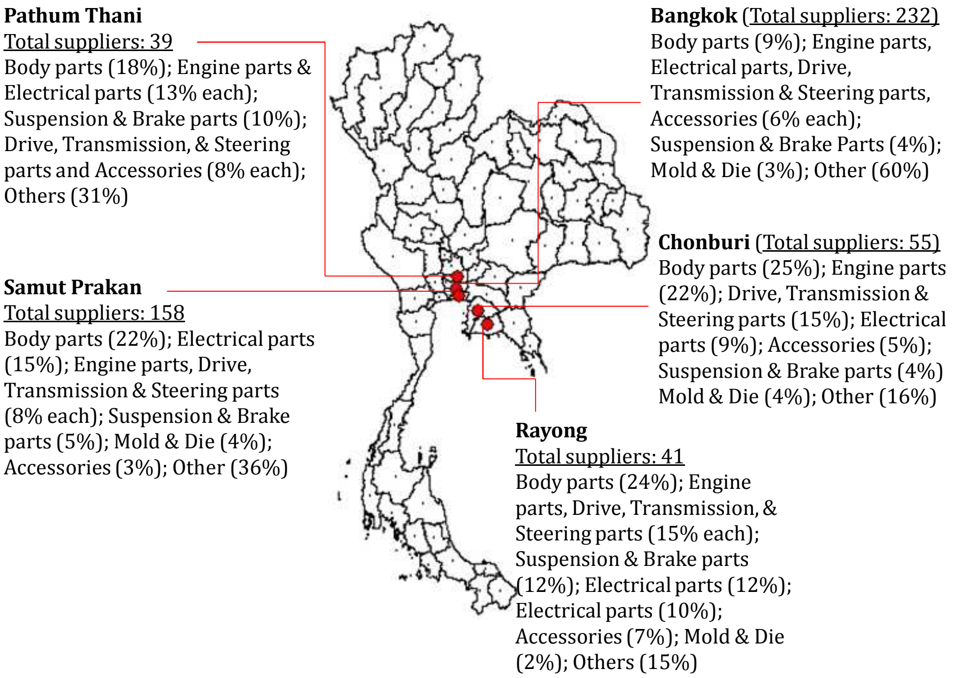
Note that this is consistent with the change in the Gini coefficient of this industry, which is discussed in Chapter 3. That is, at the industrial level, the magnitude of concentration has slightly declined from 0.829 to 0.827 during the period 1996 and 2006. Obviously, such a minimal decline is due to a limited extent of industrial decentralization. Motor vehicle establishments have not gone far away from the BMR nor even started to scatter across the country, but they have moved to provinces around Bangkok and formed a larger cluster in these areas.

Figure 4.2: Location of major automobile assemblers



Source: Inthaiwong (2007, pp.34)

Figure 4.3 Location of major automobile parts suppliers



Source: Inthaiwong (2007, p.35)

4.3.2 Spatial clustering in food products and beverages industry (ISIC15)

Spatial clustering pattern in the food products and beverages industry is different from that in the motor vehicle industry. First, the number of establishments in the BMR increased from 1,426 in 1996 to 2,261 in 2006 (or 59%), resulting in an overall increase in establishment density in this area from 19 establishments per 100 Km^2 to 32.2 establishments per 100 Km^2 (see Figure 4.4). Except in Bangkok city, the density has increased in other BMR provinces. However, despite an overall increase in the number of establishments in the BMR, its share in the whole kingdom has decreased rapidly from 30.6% to 13.8%. This is due to a large increase in the number of establishments in this industry, from 4,666 in 1996 to 16,416 in 2006 (or +252%) with most of the establishments founded after 1996 located in peripheral provinces.

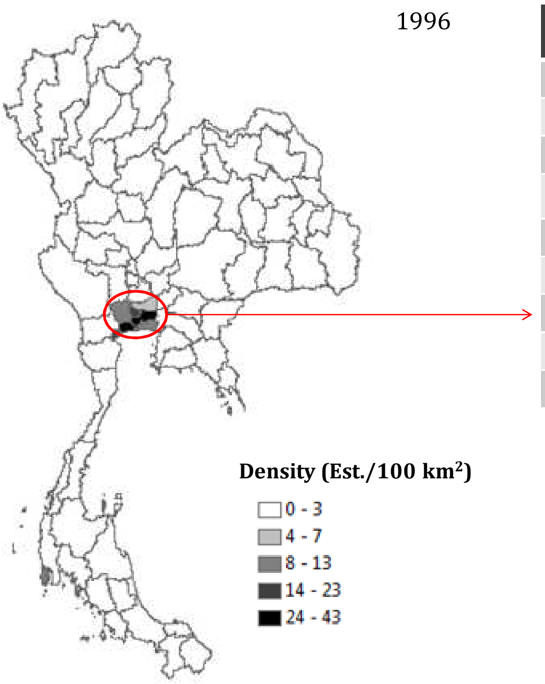
Second, based on the threshold to identify the industrial cluster, $PD_{jr} \geq PD_{j,BMR}$ (for j =

food and beverage industry), we can say that there is no food and beverage cluster in other provinces apart from the BMR. Nevertheless, I find that the number and density of establishments has increased significantly in many provinces, resulting in an increase in the degree of agglomeration of foods and beverages establishments in those provinces. Comparing the maps in Figure 4.4, we can find that establishment density has changed significantly. In 1996, a great majority of provinces did not have an establishment density of 4 or more establishments per 100 Km^2. However, 10 years later, a number of provinces registered an increased density of establishments with 4 or more establishments per 100 Km^2 (Table 4.4).

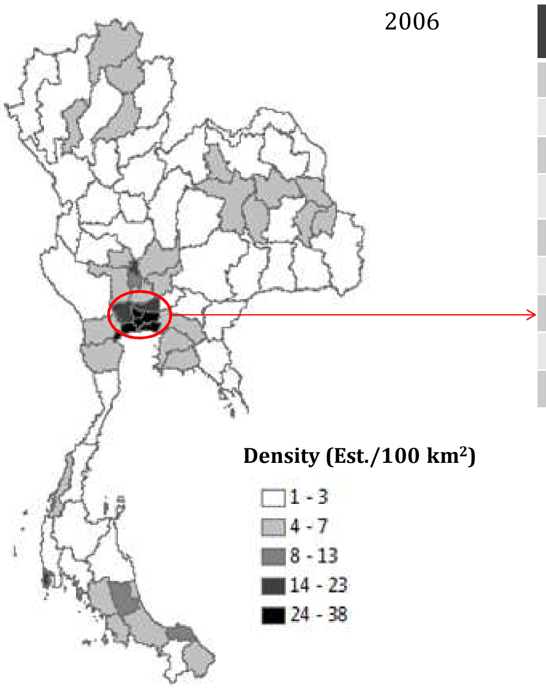
The spatial distribution pattern shown here is consistent with the finding in Chapter 3 in that overall spatial concentration of food products and beverage industry has largely declined between 1996 and 2006. Such decline is attributable to the more even spatial distribution of establishments across regions. As seen from the second map, food and beverage establishments tend to be scattered in all regions across the country. However, to some extent, establishments tend to concentrate in some provinces in each region. For example, in the North, establishments tend to concentrate in Chiang Rai, Phrae, and Phayao, which are contiguous provinces. In the Northeast, they tend to gather in the middle area covering the provinces of Khon Kaen, Kalasin, Roi Et, and Maha Sarakham.

As a result of a rapid increase in the number of food and beverage establishments during the period 1996-2006, many provinces have moved toward the formation of industrial clusters. In fact, in 1996, only 10 provinces had more than 100 food and beverage establishments, but by 2006, 24 provinces had 250 establishments or more.

Figure 4.4: Mapping of spatial clustering in food products and beverages industry



Province	#Establishments	Density
Bangkok	671	42.8
Samut Prakan	133	13.2
Samut Sakon	222	25.4
Nakhon Pathom	224	10.3
Patum Thani	84	5.5
Nonthaburi	92	14.8
# BMR Total (%)	**1,426(30.6)**	
Whole Kingdom	**4,666(100)**	
BMR Density		**19.0**



Province	#Establishments	Density
Bangkok	599	38.2
Samut Prakan	303	30.2
Samut Sakon	599	68.7
Nakhon Pathom	383	17.7
Patum Thani	235	15.4
Nonthaburi	142	22.8
# BMR Total (%)	**2,261(13.8)**	
Whole Kingdom	**16,416(100)**	
BMR Density		**32.2**

Source: Author

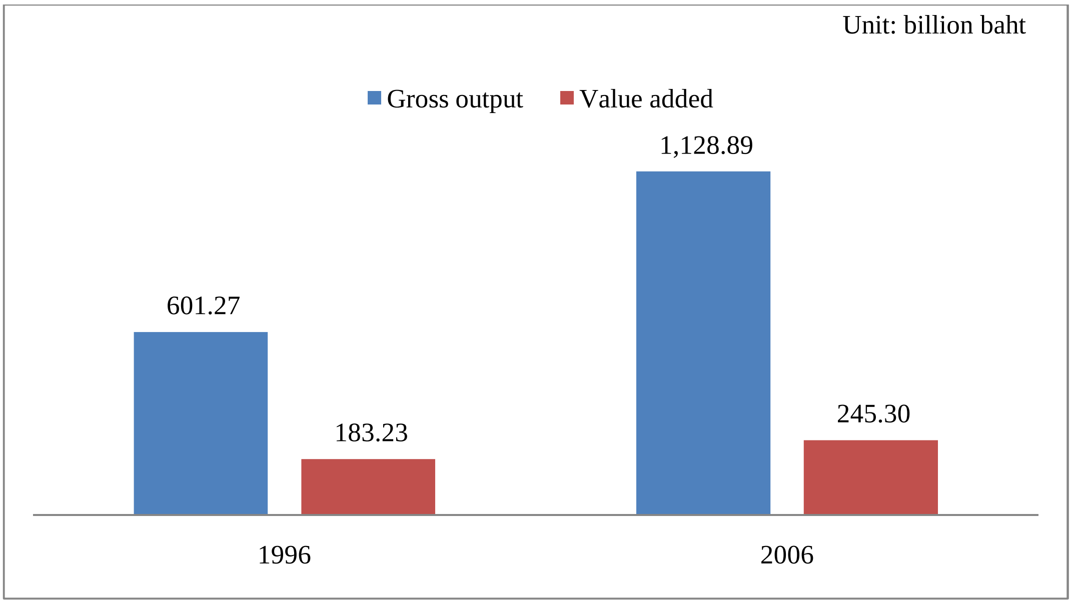
Table 4.4: Changes in number and density of food & beverage establishments (selected provinces)

	1996		2006	
	No. Establishments	**Density** [a]	**No. Establishments**	**Density** [a]
Outer-ring				
Ayutthaya	87	3.4	132	5.2
Ang Thong	15	1.5	107	11.0
Chon Buri	144	3.1	223	4.8
Ratchaburi	117	2.3	275	5.3
Samut Songkram	65	15.6	159	38.2
Centre				
Sing Buri	26	3.2	188	22.9
Chai Nat	31	1.3	174	7.0
Suphan Buri	120	2.2	229	4.3
Northeast				
Khon Kaen	110	1.0	461	4.2
Maha Sarakham	9	0.2	274	5.2
Amnat Charoen	18	0.6	152	4.8
Kalasin	37	0.5	264	3.8
Mukdahan	20	0.5	157	3.6
North				
Lamphun	53	1.2	263	5.8
Phrae	14	0.2	309	4.7
Phayao	28	0.4	324	5.1
Chiang Rai	117	1.0	490	4.2
South				
Songkhla	97	1.3	348	4.7
Satun	13	0.5	124	5.0
Trang	55	1.1	290	5.9
Phatthalung	29	0.8	280	8.2
Pattani	63	3.2	251	12.9
Narathiwat	11	0.2	182	4.1

Note: [a] Density = number of establishments per 100 Km^2.
Source: Author, based on industrial censuses 1997 and 2007

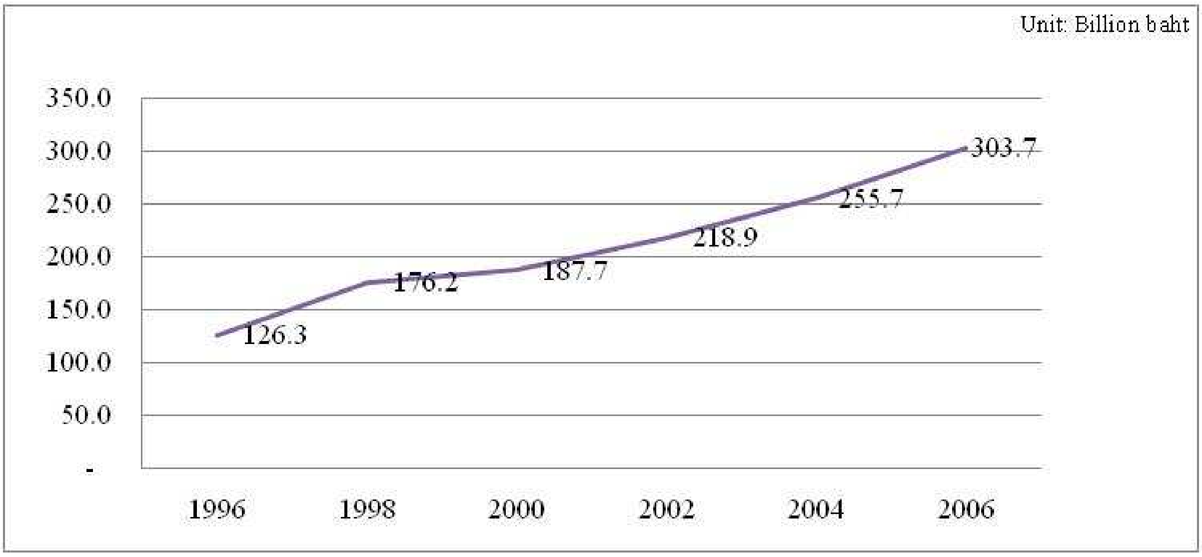
The overall growth in the number of food and beverage establishments is associated with the growth of this industry after the 1997 economic crisis. Between 1996 and 2006, gross output of this sector increased from 601.27 billion baht to 1,128.89 billion baht, and value added also increased from 183.32 to 245.3 billion baht (Figure 4.5). Similarly, export values of food products and beverages also increased during the same period. As can be seen in Figure 4.6, agro-processing products and beverages exhibit a continuous growth in export between 1996 and 2006. Looking at the value of export by product types (Figure 4.7), we can also find that most categories of food products and beverages enjoy a continuous export growth during this period, especially those leading sub-sectors such as processing seafood, fruit and vegetable products, pet foods, and wheat products.

Figure 4.5: Changes in gross output and value added of food products & beverages industry



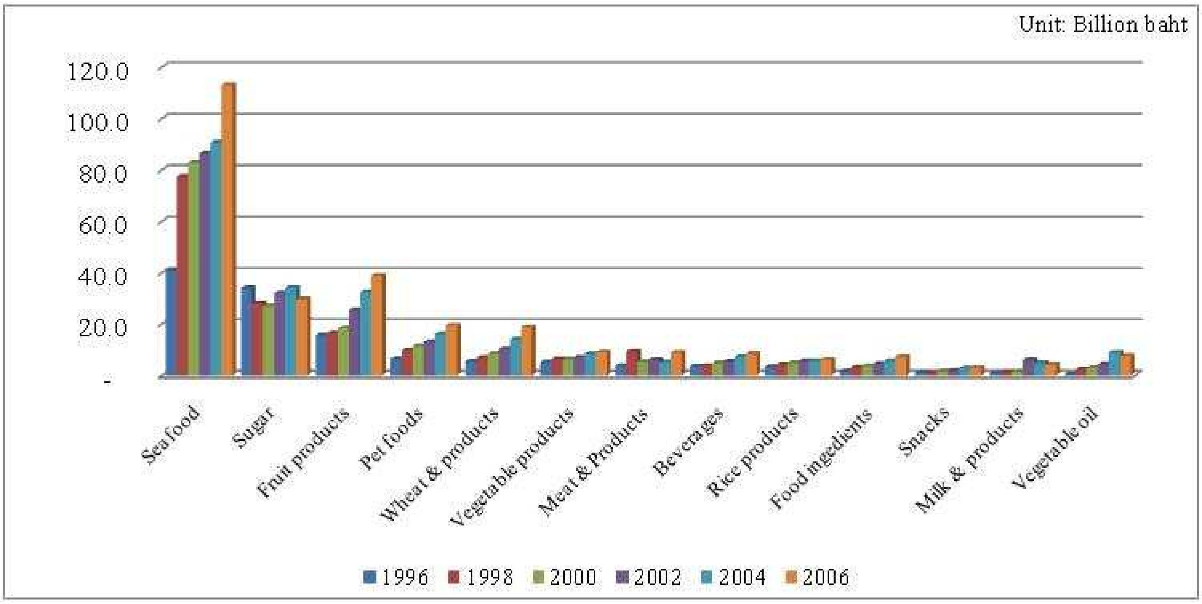
Source: Industrial censuses 1997 and 2007

Figure 4.6: Total agro-processing (all products) and beverage export values, 1996-2006



Source: Department of Export Promotion (DEP), Ministry of Commerce (MOC)

Figure 4.7: Agro-processing and beverage export values (selected product types), 1996-2006



Source: Department of Export Promotion (DEP), Ministry of Commerce (MOC)

It can be argued that the spatial distribution pattern of food and beverage establishments is a typical case of resource-based industry. That is, establishments tend to be located in regions possessing the main resources needed so that they can minimize the transportation costs by taking advantage of the weight-reducing nature of particular processes and minimizing the spoilage of raw materials (Poapongsakorn 1995). Examples of resource-based establishment locations are as follows (NFI 2002):

- Seafood processing establishments are mostly found in the coastal provinces in the south such as Songkhla, Chumphon, Phattalung, and Pattani, and in the east such as Samut Sakon and Samut Songkram;
- Fruit and vegetable processing establishments are scattered across the country based on raw materials used. For example, lychee and longan processing establishments are located in the northern provinces such as Chiang Rai, Chiang Mai, and Lamphun where both kinds of fruit are grown. Pineapple-canning factories are found in Prachuapkhiri Khan, Chon Buri, Rayong, and Kanchanaburi where pineapples are mostly produced;
- Meat processing establishments are mostly found in the BMR or the largest provinces in each region such as Songkhla in the South, Chiang Mai in the North, and Nakhon Ratchasima in the Northeast which tend to use modern production methods and have a large capital investment;
- Rice processing establishments are mostly found in the northeast (e.g. Khon Kaen, Kalasin, Mahasarakham, Nakhon Rachasima, and Udon Thani), which is the largest rice production area in the country.

It is worth noting that the food products and beverages industry in other areas does not necessarily involve only smaller-scale and less efficient activities than those in the BMR, as argued by previous studies (e.g., Tambunlertchai and Loohawenchit 1985; Poapongsakorn 1985). Recently, many of the establishments in several provinces are larger and even more efficient than those in the BMR. As shown in Table 4.5, although establishments in the BMR employ more workers (on average) than those in other provinces, average establishments' capital investment in many provinces (such as Chon Buri, Ang Thong, Samut Songkram, Khon Kaen, Lamphun, and Chinag Rai) is larger than in the BMR. In fact, it is normal to find large-scale seafood processing establishments in, for example, Songkhla and Samut Songkram, or large-scale fish sauce factories in Chon Buri. Similarly, there are a number of large fruit-canning factories in Lamphun, Chiang Mai, Chiang Rai and Chon Buri and large sugar producing establishments in Khon Kaen (NFI 2002). In terms of average establishment sales and average sales per employee (a measure of labor productivity), Table 4.5 shows that many provinces perform better than the BMR. For example, average sales of establishments in Chon Buri, Lamphun, Phayao, and Khon Kean are higher than sales of the BMR establishments; and average sales per employee (*S/L*) in most provinces except Songkhla is higher than in the BMR.

Table 4.5: Characteristics of provincial food and beverage establishments, 2006 (selected provinces)

	L	*K*	***S***	***S/L***		***L***	***K***	***S***	***S/L***
Outer-ring					**Northeast**				
Ayutthaya	60.3	112.7	216.7	3.6	Khon Kaen	15.7	77.2	218.2	13.9
Ang Thong	14.2	86.7	205	14.4	M.Sarakham	23.4	28.5	67.8	2.9
Chon Buri	91.9	82.6	237.4	2.6	A.Charoen	7.8	48.8	151.2	19.4
Ratchaburi	52.8	51.2	139.4	2.6	Kalasin	17.1	48.5	96.3	5.6
S.Songkram	29.7	42.8	124.8	4.2	Mukdahan	8.8	40.2	95.3	10.8
Centre					**South**				
Sing Buri	12.7	104	346.6	27.3	Songkhla	75.1	25.2	74	1.0
Chai Nat	8.5	43.4	116.4	13.7	Satun	16.9	33.5	86.9	5.1
Suphan	26.8	58.1	93.3	3.5	Trang	23.9	37.7	105.6	4.4
					Phatthalung	6.0	29.6	323.4	53.9
North					Pattani	30.2	100.3	95.1	3.1
Lamphun	21.9	102.8	204.9	9.4	Narathiwat	7.1	39.7	123.1	17.3
Phayao	14.7	164.3	516.3	35.1					
Chiang Rai	14.9	119.9	164.2	11.0	**BMR** (ave.)	104.6	74.4	168.3	1.6

Notes: (1) *L* = average number of employee per establishment; *K* = average capital investment per establishment in terms of fixed asset values at the beginning of 2006 (in million baht); *S* = average sales per establishment (in million baht); and *S/L* = a measure of labor productivity (in million baht per employee). (2) For the BMR, the numbers are the average of six provinces in the BMR.
Source: Author, based on industrial census 2007.

In sum, the overall increase in the number of food and beverage establishments results in higher density in the old agglomeration, i.e., the BMR. But at the same time, at the industrial level, it makes spatial distribution in this industry look more equal. This is because a larger number of establishments are scattered across the country based on the main resources used in the production processes. Another important observation is that in some provinces, the number of establishments has increased greatly, resulting in the trend toward the formation of food and beverage clusters in peripheral regions. Additionally, food and beverage establishments founded in regions other than the BMR are not necessarily smaller or less efficient than those established in the BMR. Some of them are larger and even more efficient than establishments in the BMR.

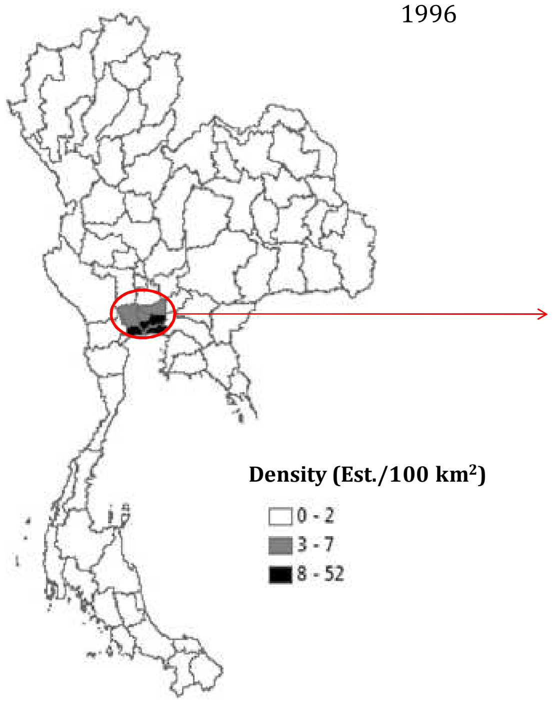
4.3.3 Spatial clustering in textile industry (ISIC17)

The textile industry exhibits a spatial distribution pattern which is similar to the food products and beverages industry. In 1996, there were 1,950 textile establishments in Thailand, and the great majority of them (77.1%) were located in the BMR (Figure 4.8). In 2006, however, the number of establishments in the whole kingdom had increased greatly to 7,893 (or 400%), whereas the number of establishments in the BMR had decreased to 1,424 (or down 10.4%). The reduction of textile establishments in the BMR is reflected in a decline in its establishment density from 19.4 establishments to 18.3 establishments per 100 km^2.

Based on the threshold $PD_{jr} \geq PD_{j,BMR}$ (for j = textile industry), I find no textile industrial clusters in provinces other than the BMR. However, it appears that the majority of new textile establishments founded after 1996 were not located in the BMR, but located in other regions, especially the Northeast and the North. As shown in Table 4.6, the number and density of textile establishments in some northeastern and northern provinces have markedly increased. Roi Et, for example, has increased the number of its textile establishments from three establishments in 1996 to 492 establishments in 2006; consequently, its establishment density has increased from 0.001 establishments per 100 km^2 to 5.9 establishments per 100 km^2. It can also be observed from Table 4.6 that a group of provinces in the middle area of the Northeast (Khon Kaen, Kalasin, Maha Sarakham, Mukdahan, and Yasothon) shows a trend toward the formation of industrial clusters. These provinces register a large growth in the number of textile establishments and currently constitute textile production bases in the country.

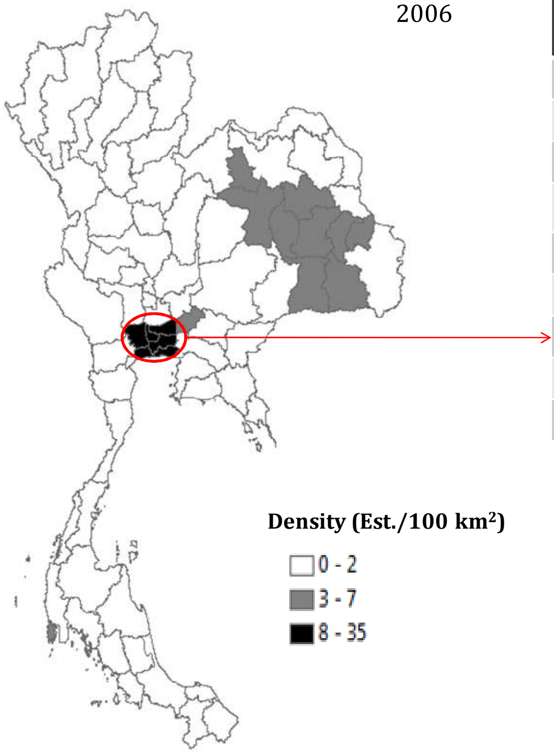
Figure 4.8: Mapping of spatial clustering in textile industry

1996



Province	#Establishments	Density
Bangkok	823	52.5
Samut Prakan	281	28.0
Samut Sakon	177	20.3
Nakhon Pathom	153	7.1
Patum Thani	49	3.2
Nonthaburi	21	3.4
# BMR Total (%)	**1,504(77.1)**	
Whole Kingdom	**1,950(100)**	
BMR Density		**19.4**

2006



Province	#Establishments	Density
Bangkok	503	32.1
Samut Prakan	352	35.3
Samut Sakon	284	32.6
Nakhon Pathom	182	8.4
Patum Thani	56	4.0
Nonthaburi	47	8.0
# BMR Total (%)	**1,424(18.2)**	
Whole Kingdom	**7,839(100)**	
BMR Density		**18.3**

Source: Author

Table 4.6: Changes in number and density of textile establishments (selected provinces)

	1996		2006	
	No. Establishments	**Density**[(a)]	**No. Establishments**	**Density**[(a)]
Northeast				
Roi Et	3	0.0	492	5.9
Si Sa Ket	21	0.2	377	4.3
Khon Kaen	50	0.5	369	3.4
Surin	2	0.0	339	4.2
Maha Sarakham	1	0.0	314	5.9
Ubon Ratchathani	8	0.0	261	1.6
Kalasin	8	0.0	218	3.1
Nong Bua Lam Phu	1	0.0	202	5.2
Buri Ram	3	0.0	179	1.7
Yasothon	0	0.0	158	3.8
Amnat Charoen	1	0.0	153	4.8
North				
Chiang Rai	15	0.1	170	1.5
Phayao	5	0.0	145	2.3
Chiang Mai	26	0.1	141	0.7

Note: [(a)] Density = number of establishments per 100 Km^2
Source: Author, based on industrial censuses 1997 and 2007

In Chapter 3, we saw that the Gini coefficient of spatial concentration in the textile industry dropped from 0.85 to 0.50 between 1996 and 2006. This is because the number of textile establishments in the BMR decreased and the number of establishments in other provinces increased, resulting in a decline in spatial concentration at the industrial level.

The decline in the number and density of textile establishments in the BMR reflects the rising costs of agglomeration in the BMR. As a result of increased agglomeration, (nominal) wages in the BMR increased continuously from 52.5 baht per day in 1980 to 413.5 baht per day in 2005 (Figure 4.9). Compared with other textile exporters, by 2000, Thailand's average wage for textile workers was about twice as high as the wage in China and India, three times higher than the wage in Vietnam and Pakistan, and four times higher than in

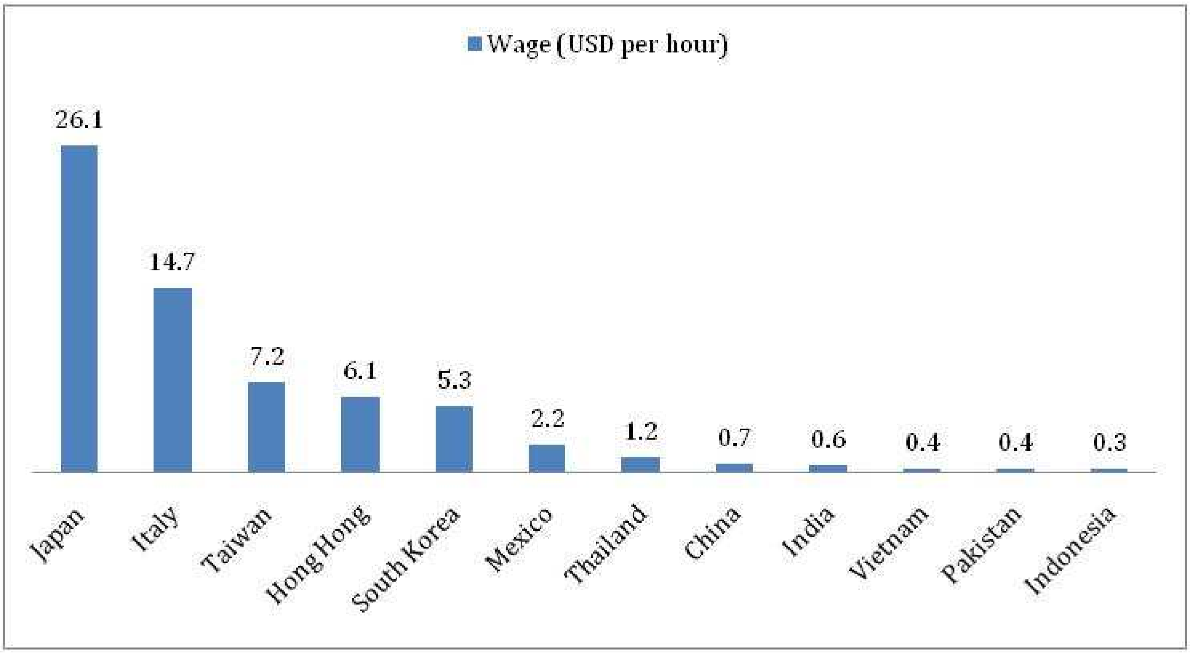
Indonesia (Figure 4.10). Consequently, this affects the competitiveness of textile products from Thailand in major export markets such as the US, the EU and Japan. Recently, Thailand has been losing its competitiveness to the main exporters in the world textile export markets such as China, India, Vietnam, and Indonesia.[49] At the same time, Thai textile producers are also facing high competition in the domestic market from cheaper imported products, especially in the fabrics product line, and this competition has been increasing in recent years (Figure 4.11).

Figure 4.9: Change in nominal wage in the BMR, 1980-2005

Source: Labor Force Survey (selected years), NSO

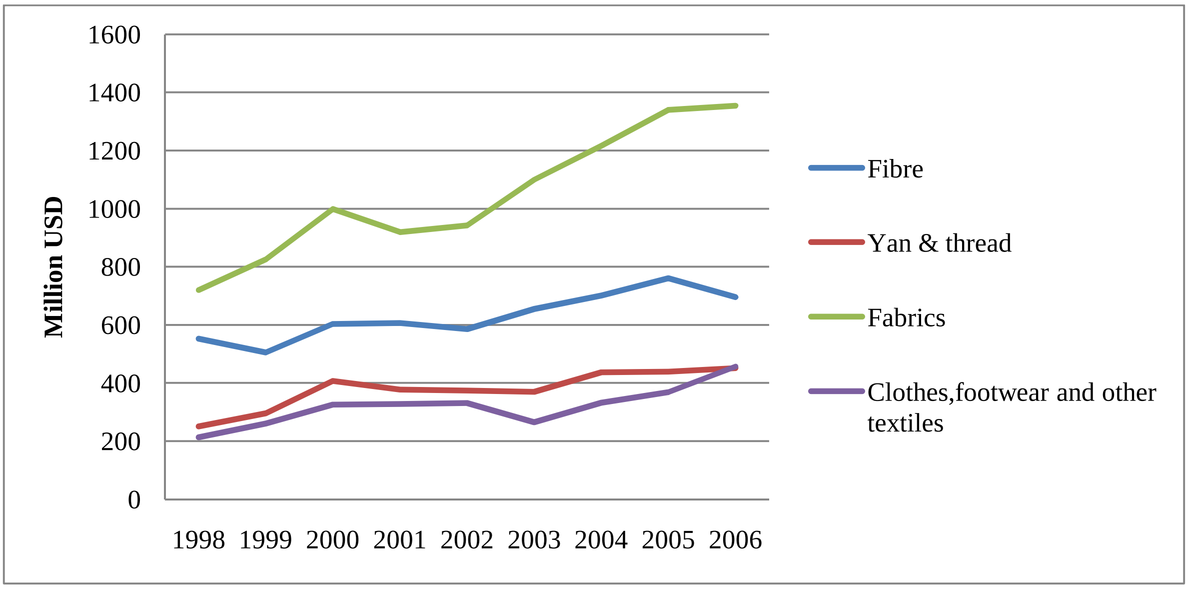
[49] The Thai share of the import of textile products in the US fell from 1.9% in 2000 to 1.6% in 2006; in the EU, from 2.0% in 2000 to 1.3% in 2006; and in Japan, from 7.5% in 2000 to 1.4% in 2006 (Author's calculation from textile statistics provided by Thailand Textile Institute and WTO). At the same time, Vietnam – a key competitor of Thailand – has constantly increased its exports to such major markets as the US and Japan. By the beginning of the 2000s, Vietnam's export to these countries had already exceeded that of Thailand. For example, in 2003 (the first time that Vietnam's exports exceeded that of Thailand to the US market), Vietnam's textile export to the US was 1,998.5 million US$, while Thailand's export was 1,870 million US$. In 2005, while Vietnam increased its export to 2,729 million US$ in the US market, Thailand's export to the US was only 2,111 million US$. According to some report, Thailand is projected to completely lose its competitiveness in textile export against Vietnam in key markets in the near future (OIE 2006).

Figure 4.10: Average wages for textile workers in key textile exporting countries, 2000



Source: Textile Statistics, Thailand Textile Institute (THTI)

Figure 4.11: Trends in import of textile products, 1998-2006



Source: Textile Statistics, Thailand Textile Institute (THTI)

Since labor costs in the BMR are too high, most of the newly established textile establishments (those begun after 1996) tend to be located in the Northeast and the North where labor costs are still relatively low as compared to Bangkok. As in Table 4.7, nominal wages of the Northeast and the North are less than the BMR's nominal wage, and still lower than two other regions – the Centre and the South. This makes the Northeast and the North more attractive for textile establishments. When we compare the minimum wage rates between the BMR and the provinces where the number of establishments has rapidly increased, we find that minimum wage rates in those provinces are much lower (Table 4.8). For example, minimum wage in Khon Kaen – one of the most developed provinces in the Northeast – was only 136 baht per day in 2003, much lower than the minimum wage of 169 baht per day in the BMR in the same year. Even in Chiang Mai – the most developed province in the North – the minimum wage is still much lower than in the BMR.[50]

Table 4.7: Nominal wage by regions

	2003	**2004**	**2005**	**2006**
				Unit = Baht per month
BMR	10,782	11,152	12,406	12,949
Northeast	4,905	5,147	5,529	6,252
North	4,962	5,263	5,568	5,840
Centre	6,856	6,973	7,365	7,822
South	5,468	5,700	6,162	6,681
BMR = 100	100	100	100	100
Northeast	45.5	46.1	44.6	48.3
North	46.0	47.2	44.9	45.1
Centre	63.6	62.5	59.4	60.4
South	50.7	51.1	49.7	51.6

Source: Labor Force Survey, NSO

[50] Note that the government-mandated minimum wage is generally lower than nominal wage because it does not totally reflect the private sector demand for labor. In fact, it is very likely that the gap between nominal wage and minimum wage will be higher in large urban areas than in rural areas because labor demand and labor quality tend to be higher in urban areas.

Table 4.8: Minimum wages (as of January 1, 2003-2006) in selected provinces

	2003	**2004**	**2005**	**2006**
				Unit : Baht per day
BMR	169	170	181	184
Northeast				
Roi Et	133	135	139	142
Si Sa Ket	133	135	139	142
Khon Kaen	136	136	140	144
Surin	133	133	137	141
Maha Sarakham	133	133	138	142
Ubon Ratchathani	133	133	137	141
Kalasin	135	135	139	144
Nong Bua Lam Phu	135	135	139	142
Buri Ram	136	136	140	144
Yasothon	133	133	137	142
Amnat Charoen	133	135	139	141
North				
Chiang Rai	133	133	137	142
Phayao	133	133	137	140
Chiang Mai	143	145	149	155

Source: Department of Labor Protection, Department of Labor (DOL)

In sum, the spatial distribution in the textile industry underwent an important change between 1996 and 2006. Although the BMR is still the main textile cluster, textile establishments tend to be less agglomerated in the BMR due to its high labor costs. More textiles establishments have been founded in provinces where they can easily find cheap labor. This adjustment seems to be necessary as the Thai textile industry is now facing more intense competition in export markets as well as in domestic markets. Many establishments have opted to be located in the northeastern and northern provinces which have low labor costs. As a result, there appear the emerging textile clusters in those provinces.

4.4 Determinants of industrial clustering

We have observed from the previous section that although the BMR is still the only industrial cluster in Thailand, emerging clusters have appeared in the provinces other than the BMR. In this study, the term "emerging clusters" refers to the provinces which are moving toward the formation of industrial clusters. The analysis that follows in this section distinguishes the location of establishments in industrial clusters from the location of establishments in emerging clusters. Thus, the determinants of establishments' location in the BMR (as an industrial cluster) and the determinants of establishments' location in the emerging clusters are examined separately. This is to see whether the factors influencing the establishments' decision to be located in the already-established industrial clusters differ from those influencing the establishments' decision to be located in the place which might be an industrial cluster in the future.[51] Note that the analysis of establishments' location in emerging clusters can be viewed as the examination of cluster formation, while the analysis of establishments' location in the BMR can be viewed as the examination of cluster existence.

In the three selected industries (motor vehicles, food products and beverages, and textiles), the emerging clusters include the provinces as follows:

- In the motor vehicle industry, the emerging cluster includes Chon Buri, Chachoengsao, Rayong, and Ayutthaya. It should be noted that although the location of motor vehicle establishments in these four provinces can be considered as an expansion of the motor vehicle cluster from the BMR, analyzing these provinces separately from the BMR is relevant for several reasons. First, as the agglomeration of motor vehicle establishments in Chon Buri, Chachoengsao, Rayong, and Ayutthaya has occurred after the motor vehicle agglomeration had taken place in the BMR, it is interesting to see why these four provinces have attracted

[51] In other words, the analysis of the determinants of establishments' location in the emerging clusters aims at examining the factors which influence the movement of provincial industries toward becoming industrial clusters.

many motor vehicle establishments, and whether the determinants of establishments' decision to be located in these provinces differ from the determinants of establishments' decision to be located in the BMR. Second, by 2006, the degree of motor vehicle agglomeration (measured by the density of establishments) in Chon Buri, Chachoengsao, Rayong, and Ayutthaya was still lower than that in the BMR (see Figure 4.1); thus, we can still consider these four provinces as an emerging cluster, instead of an established cluster. Finally, in the previous studies on industrial location in Thailand (e.g., Kittiprapas and McCann 1999; Techakanont 2008), the BMR and these four provinces are treated as separate regions. Those studies also find that the factors explaining the location of firms in the BMR differ from those explaining the location of firms in Chon Buri, Chachoengsao, Rayong, and Ayutthaya. Therefore, I analyze the BMR and these four provinces separately in order to compare the results of this study with those of previous studies;[52]

- In food and beverage industry, the emerging clusters include Ayutthaya, Ang Thong, Chon Buri, Ratchaburi, Samut Songkram, Sing Buri, Chai Nat, Suphan Buri, Khon Kaen, Maha Sarakham, Amnat Charoen, Kalasin, Mukdahan, Lamphun, Phrae, Phayao, Chiang Rai, Songkhla, Satun, Trang, Phatthalung, Pattani, Narathiwat (listed in Table 4.4).

- In textile industry, the emerging clusters are Roi Et, Si Sa Ket, Khon Kaen, Surin, Maha Sarakham, Ubon Ratchathani, Kalasin, Nong Bua Lam Phu, Buri Rum, Yasothon, Amnat Charoen, Chiang Rai, Phayao, Chiang Mai (listed in Table 4.6).

Therefore, in this section, the analysis of establishments' location decision can be divided into (1) establishments' decision to be located in the industrial cluster (the BMR); and (2) establishments' decision to be located in emerging clusters (provinces identified above). I first discuss the theoretical model of establishment location and draw from the previous

[52] However, in order to take into account the entire spatial scope of industrial clustering, I also conducted the analysis that treats the BMR and Chon Buri, Chachoengsao, Rayong, and Ayutthaya as the same industrial cluster (see Subsection 4.5.2, part a).

theoretical and empirical literature hypotheses to be tested. Then, I discuss variable construction and data issues. The result of this statistical analysis is presented in Section 4.5.

4.4.1 Theoretical model of establishment location

Following standard practice in the literature on a firm's location choices (Levinson 1996; Kittiprapas and McCann 1999; Guimaraes et al. 2000; Mucchielli and Puech 2004; Hong 2007), I assume that the profit (π) of establishment *i* in province *k* is determined by the establishment's characteristics (U_{ik}) as well as provincial characteristics (W_k) and can be presented in a functional form as follows:

$$\pi_{ik} = f(U_{ik}, W_k) \tag{1}$$

I further assume that establishment *i* decides to be located in province *k* when it expects to receive higher profit by being located in *k* as compared to being located in other provinces, that is:

$$\pi_{ik} - \pi_{ir} > 0 \tag{2}$$

where $k, r \in R$ (set of provinces in Thailand) and $k \neq r$.[53] Equation (2) represents a standard case.

Now let us move to the specific case regarding *k*. It follows from equation (2) that establishment *i* decides to be located in a province in the BMR (industrial cluster)[54] when it expects to receive higher profit by being located in a province in the BMR as compared to being located in other provinces. In this case, we will specify *k* in equation (2) by k^*, where $k^* \in$ BMR $\in R$. This can be written as:

$$\pi_{ik^*} - \pi_{ir} > 0 \tag{3}$$

[53] There are 76 provinces in Thailand, so that $R = \{r_1, r_2, ...,r_{76}\}$.
[54] The BMR (or the Bangkok Metropolitan Region) consists of six provinces including Bangkok, Nonthaburi, Nakhon Pathom, Pathum Thani, Samut Prakan, and Samut Sakon.

Similarly, establishment *i* decides to be located in a province in the emerging clusters[55] (denoted by *E*) when it expects to receive higher profit by being located in a province in the emerging clusters as compared to being located in other provinces. In this case, we will specify *k* in equation (2) by k^{**}, where $k^{**} \in E \in R$. This can be written as:

$$\pi_{ik^{**}} - \pi_{ir} > 0 \tag{4}$$

To avoid confusion, the differences between equations (3) and (4) should be noted. As mentioned before, this study not only investigates the location of establishments in the industrial cluster (the BMR), but it also investigates the location of establishments in the emerging clusters. Therefore, equation (3) denotes the establishment's decision to be located in the industrial cluster, while equation (4) denotes the establishment's decision to be located in the emerging cluster.[56]

The profit (π) is a latent variable[57] whose value cannot be directly observed but can be linked to the observed binary variable Y_{ik} by the measurement equation (Long 1997, p.41). In a standard case, this can be expressed as:

$$Y_{ik} = f(U_{ik}, W_k) = \begin{cases} 1 & if \;\; \pi_{ik} - \pi_{ir} > 0 \\ 0 & if \;\; \pi_{ik} - \pi_{ir} \leq 0 \end{cases} \tag{5}$$

Now, dependent variable Y_{ik} is observed and takes binary outcomes – 0 or 1. In equation (5), variable Y_{ik} denotes whether an establishment is located in *k*. It takes 1 if an establishment is located in *k* and 0 otherwise.

Since this study aims to analyze the probability that establishments will be located in the BMR or in the emerging clusters (*E*), *k* in equation (5) is replaced by k^* and k^{**},

---

[55] The list of provinces defined as the emerging clusters for each of three selected industries is provided above.

[56] Note that, in this study, each establishment is located in one province only, not in several provinces (as in the case of multi-locational establishments). The purpose of distinguishing between equations (3) and (4) is to see whether the determinants of establishments' location in the industrial cluster differ from the determinants of establishments' location in the emerging clusters.

[57] For a comprehensive discussion about the latent variable, see Long (1997, pp.40-47)

respectively. Then,

$$Y_{ik^*} \;=\; f(U_{ik^*}, W_{k^*}) = \begin{cases} 1 & if \;\; \pi_{ik^*} - \pi_{ir} \; > \; 0 \\ 0 & if \;\; \pi_{ik^*} - \pi_{ir} \; \leq \; 0 \end{cases} \qquad (6)$$

where $k^* \in$ BMR.

And similarly,

$$Y_{ik^{**}} \;=\; f(U_{ik^{**}}, W_{k^{**}}) = \begin{cases} 1 & if \;\; \pi_{ik^{**}} - \pi_{ir} \; > \; 0 \\ 0 & if \;\; \pi_{ik^{**}} - \pi_{ir} \; \leq \; 0 \end{cases} \qquad (7)$$

where $k^{**} \in E$.

What we are interested in here is independent variables (U_{ik^*}, W_{k^*}) and ($U_{ik^{**}}$,$W_{k^{**}}$) which denote establishment and provincial characteristics, respectively. I discuss them as follows.

4.4.2 Hypothesis and independent variables

a. Establishment's characteristics

The first set of independent variables includes some of the establishment's characteristics which may affect the establishment's decision to be located in the BMR and in emerging clusters.

First, it is proposed by Krugman (1991a) that if establishments' scale economies are sufficiently large relative to transportation costs, then establishments tend to locate their production site in one place and supply their products from that location. Based on this argument, it is possible to assume that large establishments are more likely to be located in an industrial cluster than small establishments. However, Kim et al. (2000) hypothesizes that the potential effect of large establishments on industrial clustering is not quite clear. According to them, large establishments will contribute to industrial clustering if large establishments encourage the spin-off of new establishments, if they can sufficiently attract input suppliers and specialized business services to serve them, or if they can generate the pool of labor with specialized skills. Conversely, large establishments may discourage agglomeration if their presence leads to higher local input prices or if they do not have local input purchases but source from distant markets instead. To test these hypotheses, I use the variable *SIZE* as a proxy for establishment-level scale economies. This variable is measured by the natural logarithm of the number of fulltime employees.[58] The effect of this variable is expected to be either positive or negative.

Second, establishment's input demand linkages are proposed as a factor in determining its decision to be located in the cluster (Venable 1994; Barde 2010). Venable (1994) establishes that forward and backward linkages between upstream and downstream industries encourage the agglomeration of establishments. According to him, when establishments are agglomerated, it will generate larger demands for intermediate inputs. As the number of establishments in a location increases, the costs of intermediate inputs will be lower because fewer intermediate suppliers will bear transport costs. With sufficient backward and forward linkages between upstream and downstream industries, it will create positive externalities and encourage further agglomeration (Venable 1994).[59] Following Homes (1999), I use variable *INPUT*, which is defined as an establishment's purchased inputs as a share of its output value, to examine whether input demand linkages significantly affect the likelihood that establishments may be located in the cluster. I expect the effect of *INPUT* be positive, which

[58] An alternative variable to capture establishment size would be establishments' registered capital. However, since this variable has many missing values which may affect the reliability of the estimation, I decide to use the number of fulltime workers employed by establishments instead.
[59] Barde (2010) verifies Venable (1996)'s argument and empirically shows that positive spillovers generated by industry linkages will decrease with distance and will disappear when transport costs increase further. This implies that, because establishments want to gain benefits from such positive spillovers, they are likely to be located in the industrial cluster.

means that establishments that have a larger share of purchased inputs (i.e., less vertically integrated establishments) are more likely to be located in industrial clusters (or emerging clusters) than establishments that have a smaller share of purchased inputs (i.e., more vertically integrated establishments).

Third, in the literature on foreign direct investment (FDI) location, it is argued that the location choices of foreign-owned establishments are affected by their disadvantages in obtaining necessary information for investing in the host country (Caves 1971). Compared to locally-owned establishments, foreign-owned establishments face more difficulties and higher costs of obtaining market information, finding local suppliers, recruiting skilled labor, and identifying risks associated with social, economic, and political uncertainties in the host country. Facing such high transaction costs, foreign establishments with risk-averse behavior tend to make a location choice based on the previous establishments' agglomeration. Thus, they are more likely than locally-owned establishments to be spatially agglomerated (Guimaraes 2000; He 2002; Mucchielli and Puech 2004). As a result, agglomeration economies generated from industrial clustering work to attract more foreign establishments (Dunning 1998; Cheng and Kwan 2000; Pelegrin 2003). In this study, I use a dummy variable *FOR* to test whether foreign-owned establishments are more likely than Thai-owned establishments to be located in the industrial clusters (or in emerging clusters). Establishment *i* is defined as foreign-owned establishment if it has a FDI share of 50% or more, otherwise it is defined as a Thai-owned establishment.[60] This dummy variable is coded 1 if an establishment is foreign-owned and 0 if it is Thai-owned. I expect a positive coefficient for the variable *FOR*. That is, foreign-owned establishments are more likely than Thai-owned establishments to be located in the industrial clusters (or in emerging clusters).

[60] This definition is based on Thailand's Foreign Business Act 1999.

Fourth, According to some studies (e.g., Becchetti and Rossi 2000; Antonietti and Cainelli 2009), it is argued that face-to-face interactions between establishments in industrial clusters facilitate the exchange of information about export markets. Thus, establishments are motivated to be located in industrial clusters to benefit from spillovers of information on exports. To test this argument, I use a dummy variable *EXP* to denote the establishment's exports. The dummy is coded 1 if an establishment exports its products and 0 if it does not. Positive effects of *EXP* are expected: establishments which sell their products abroad are more likely to be located in the industrial clusters (or in emerging clusters) than those which sell their products solely in the domestic market. This is because industrial clusters facilitate the exchange of information on exports which is more important for those who target export markets than those who target domestic markets.

Fifth, it is argued that establishments decide to be located in an industrial cluster in order to benefit from information and knowledge spillovers (Audretsch and Feldman 1996). However, independent establishments and branches can differ in the way that they acquire knowledge and information (He 2004). Branch establishments embedded in a multi-establishment firm structure can obtain knowledge and information from other establishments in the same firm structure or from the firm's central R&D unit, or they may gain direct technical support from their parent company (McCann and Simonen 2005). This indicates that geographically bonded knowledge spillovers may be less important for them. On the other hand, independent establishments, without technical supports from a parent company or from other establishments in the same firm structure, are more likely to be located in industrial clusters in order to benefit from knowledge spillovers in the clusters (He 2004). To test this argument, I use a dummy variable *INDEP* which is coded 1 if an establishment is an independent establishment and 0 if it is branch plant or subsidiary company. I expect this variable to have a positive coefficient.

Sixth, an establishment's location choice may be affected by characteristics of workers that that establishment employs or activities that it undertakes. An establishment employing low-skilled workers and carrying out routine activities tends to be more sensitive to labor costs than an establishment employing high-skilled workers and producing differentiated products (Blanchflower and Oswald 1994; Kittiprapas and McCann 1999). As wages tend to be higher in industrial clusters (Gibbs and Bernat 1997; Yao 2008), it can be argued that establishments which are more sensitive to labor costs (i.e., establishments with a large share of unskilled labor) are more likely to be located outside the cluster. On the other hand, establishments which rely on skilled labor tend to be located in the cluster, which has a large pool of skilled labor (Kittiprapas and McCann 1999). I examine the effects of skills content on an establishment's decision to be located in the cluster (or in emerging clusters) by using the variable *SKILL*. This is a continuous variable and is defined as the share of skilled labor in an establishment's total employment. Based on the above argument, I expect a positive effect of this variable.

b. Provincial characteristics

The second set of independent variables includes some of a province's characteristics which can be argued to affect an establishment's location decision.

First, the resource-based approach (Kim 1995; Ellison and Glaeser 1997; Kim 1999; Roos 2005) proposes that the location of industrial production in a particular region is determined by a region's factor endowment. A region will specialize in producing and exporting goods that require intensive use of factors relatively endowed in that region (Schott 2000; Epifani 2005). Establishments tend to be agglomerated in regions with large supplies of labor and capital (Amiti 1999; Traistaru et al. 2002; Akita et al. 2006) or in regions endowed with raw materials and natural resources (Kim 1995; Kim1999). In addition, Audretsch and Feldman (1996) argue that skills and knowledge affect an establishment's location. According to them, regional endowments in skilled workforce and knowledge (measured by R&D and innovation intensity) significantly determine the concentration of innovative establishments. In this study, I use variables *RES*, *LAB*, and *SKWF* as proxies for a province's endowments in natural resource, labor, and knowledge, respectively. *RES* is defined as the share of value-added from the resource-based sector (including agriculture, fishery, mining and quarrying, and electricity, natural gas and water supply sectors) in the total gross provincial products (GPP). *LAB* is the number of working population (i.e., population aged 15-59) in the province. *SKWF* is defined as the provincial share of the working population with tertiary education. Each of these variables is expected to have a positive coefficient.

Second, it is agued by Krugman (1991a, 1991b) and Fujita (2007) that regional market size matters for agglomeration. According to them, increasing returns can be reached when establishments locate their production site in a location with large market demand from other establishments. Thus, it is likely that establishments will be attracted to the location where industries are agglomerated. In other words, previous agglomeration positively affects establishments' location choice in industrial clusters. I test this assumption by using the variable *AG96*, which is defined as the logarithm of the number of establishments in the same industry and same province in 1996. This variable is expected to have a positive coefficient.

Third, it can be argued that some policies may have effects on establishments' location choices. In this study, I test this by including the variable *IE* which is a dummy variable signifying whether province *r* has industrial estates. *IE* takes 1 if province *r* has at least one industrial estate and 0 if it has none. Industrial estates can provide establishments with some modern infrastructure and such incentives as tax reduction and ready information and thus encourage the agglomeration. Hence, I expect a positive effect of this variable.

Taking all variables together, we can form the linear model as follows (the theoretically-expected sign of each coefficient is in parenthesis):

$$
\begin{aligned}
Y_{ir} = \; & \alpha + \beta_1 SIZE_{ir} + \beta_2 INPUT_{ir} + \beta_3 FOR_{ir} + \beta_4 EXP_{ir} + \beta_5 INDEP_{ir} \\
& + \beta_6 SKILL_{ir} + \gamma_1 RES_r + \gamma_2 LAB_r + \gamma_3 SKWF_r + \gamma_4 AG96_r \\
& + \gamma_5 IE_r + \varepsilon_{ir} \qquad (8)
\end{aligned}
$$

where

Y_i = Binary dependent variable taking 1 if establishment *i* is located in the industrial cluster (or the emerging cluster), otherwise taking 0;

$SIZE_{ir}$ (+/ –) = Log. number of fulltime employees of establishment *i*;

$INPUT_{ir}$ (+) = Share of purchased inputs in sales of outputs;

FOR_{ir} (+) = Dummy for foreign-owned establishment taking 1 if establishment *i* is foreign-owned establishment and 0 if it is Thai-owned;

EXP_{ir} (+) = Dummy for export establishment taking 1 if establishment *i* exports its products and 0 if it does not export;

$INDEP_{ir}$ (+) = Dummy for independent establishment taking 1 of establishment *i* is an independent establishment and 0 if it is a branch establishment;

$SKILL_{ir}$ (+) = Share of workers with tertiary education in establishment *i*;

RES_r (+) = Log. province *r*'s GPP from resource-based sectors, 2000-05 (ave.);

LAB_r (+) = Log. province *r*'s number of working population, 2005-06 (ave.);

$SKWF_r$ (+) = Share of province *r*'s working population with tertiary education, 2005-06 (ave.);

$AG96_r$ (+) = Log. number of establishments in the same province and same industry with establishment *i* in 1996;

IE_r (+) = Dummy for industrial estate taking 1 if province *r* has industrial estate(s) and 0 if it does not.

4.4.3 Data

The data used for the regression analysis are derived from various sources. First, the NSO's industrial census 2007 is used mainly to construct the dependent variable and establishment-level independent variables. The industrial census 2007 provides information on the location of establishments at the provincial and regional level as well as information concerning industrial sectors of establishments disaggregated to 2-digit, 3-digit, and 4-digit levels. Additionally, it also provides direct information on: (1) number of fulltime workers; (2) share of purchased inputs in total sales; (3) share of workers with at least tertiary education; (4) foreign equity share; (5) share of export in total sales; and (6) ownership of establishments (independent or branch establishments). These are necessary data for constructing the establishment-level independent variables. Second, data concerning resource-based GPP, number of working population, and share of working population with tertiary education are compiled from NSO's provincial statistical reports for various years. Finally, data on location of industrial estates are provided by the Industrial Estate Authority of Thailand (IEAT).

4.4.4 Estimation strategy

It is argued that the linear regression method (i.e., Linear Probability Model: LPM) which is based on the Ordinary Least Square (OLS) procedure is no longer useful when we deal with a dependent variable having binary outcomes (Wooldridge 2006, p.529). This is because in order to estimate the model with a binary dependent variable the linear method must violate basic OLS assumptions. For example, in LPM, the variances of errors depend on the values of independent variables; thus, the assumption of homoscedasticity in errors no longer holds. Also, as dependent variables can only have the values 0 and 1, the errors cannot be normally distributed.[61] Additionally, estimating binary dependent variables by LPM is very likely to result in nonsensical predictions. For example, it is possible to get a negative probability or probability or more than 1 (Long 1997, pp.38-40; Gujarati 2003, pp.582-593).

In this study, the binary logistic regression, a regression method used specifically to deal with binary dependent variables, is employed.[62] This method predicts the *probability* that an event will occur based on non-linear method. In our context, logistic regression assumes two mutually exclusive alternatives and estimates the probability that an establishment will be located in the BMR (or in the emerging cluster) based on the following procedure:

$$P(Y_i) = \frac{e^{(\alpha+ \beta_1 SIZE_{ir}+ \beta_2 INPUT_{ir}+ \ldots+ \gamma_4 AG96_r+\gamma_5 IE_r+ \varepsilon_{ir})}}{1+e^{(\alpha+ \beta_1 SIZE_{ir}+ \beta_2 INPUT_{ir}+ \ldots+ \gamma_4 AG96_r+\gamma_5 IE_r+ \varepsilon_{ir})}} \qquad (9)$$

where $P(Y_i)$ is the probability that establishment i will be located in the BMR (or in the emerging cluster); e is the base of natural logarithm; and the other coefficients are from the linear model (equation (8)). Equation (9) has a logistic distribution and is estimated by Maximum-Likelihood (ML) method.[63]

As this study attempt to estimate the probabilities that establishments will be located in the BMR (as an industrial cluster) as well as in provinces that show a trend toward the

---

[61] For example, as Y_i is either 0 or 1 and $E(Y_i|X_i) = \beta_1 + \beta_2 X_i + \varepsilon_i$, then $\varepsilon_i = 1 - E(Y_i|X_i)$ or $\varepsilon_i = 1 - E(Y_i|X_i)$. Hence, ε_i cannot be normally distributed.

[62] Another method is binary probit model. Generally logistic and probit regression yield similar results, but they are different in how they interpret the results (see Long 1997, pp.50-83).

[63] See Hosmer and Lemeshow (2000) for a comprehensive discussion on the logistic regression method.

formation of industrial clusters (emerging clusters) in each industry. Therefore, equation (9) will be used to estimate these two dependent variables separately. For the analysis of establishments' location in the industrial cluster (the BMR), the logistic regression estimates the BMR location against other locations (i.e., all other provinces in the country), taking the latter as the comparison (base) group. For the analysis of establishments' location in the emerging clusters, the logistic regression estimates the location of establishments in provinces identified as emerging clusters against the BMR, taking the BMR as the comparison group.

In applied work, logistic regression is normally estimated by statistical software. In this study, I used SPSS software for running logistic regression. Variables were entered into the model using *force-entry mode* because it allows researchers to make their own judgment regarding model specifications, instead of relying on pure statistical procedures (Field 2005, pp.159-162).

4.5 Estimation results

4.5.1 Establishments' location in the industrial cluster (the BMR)

Before running regression, I explored the data to see whether each variable revealed some characteristics that might cause methodological problems. The same processes of data exploration were repeated across the three selected sectors. First, I conducted cross-tabulation analysis, i.e., cross-tabulating the binary dependent variable with each categorical dependent variable to see whether any cross-tabulation table contains any cells with zero. Second, I plotted the binary dependent variable against each continuous independent variable to see whether the problem of complete separation presented in the data. These data exploration procedures revealed no zero-cell and no complete separation problems. Thus, no errors are caused by these two data problems (see Field 2005, pp.264-265). Finally, I conducted binary correlation analyses to trace the correlations among each pair of variables. The results for each industrial sector are presented as a correlation matrix in Appendix 4.2. Looking for the correlations between each pair of independent variables, it is found that the variable $AG96_r$ tends to exhibit high correlations with some of the province-level independent variables. Thus, in the regression analysis, $AG96_r$ was separated from the variables with which it has high correlations in order to avoid multi-collinearity problem. Also, as complementary information, descriptive statistics for each variable are given in Appendix 4.1.

Tables 4.9-4.11 present the results of logistic regression analysis for the vehicle industry, food products and beverage industry, and textile industry, respectively. In each table, four model specifications (denoted by (1), (2), (3), and (4)) are reported: the first specification includes establishment-level variables only; the second specification includes province-level variables only (excluding $AG96_r$ due to its high correlations with other province-level variables); the third specification include establishment-level variables and $AG96_r$; and the last specification include both establishment-level and province-level variables. In each table, I report both the coefficients of explanatory variables and the exponentiation of these coefficients (i.e., *Exp (B)*). This is to facilitate the interpretation of the results in terms of the change in odds resulting from a unit change in the explanatory variable.[64] I discuss the results for the variables as follows.

First, the effects of the establishment size variable ($SIZE_{ir}$) are consistent and robust in all industries. That is, its coefficients are always positive and highly significant (at 1% level) in most specifications. This indicates that, for all three sectors, larger establishments are more likely than smaller establishments to be located in the BMR. In other words,

[64] *Exp (B)* does not require a logarithmic transformation for interpretation. It represents the proportionate change in odds after a unit change in predictor. If the value is greater than 1 then it indicates that as the predictor increases, the odds of the outcome occurring (in this case, probability that an establishment will locate in the BMR) increase (Field 2005, pp.240-242).

establishment-level scale economies are more prevalent in the BMR than in other areas.

Second, the coefficients of the $INPUT_{ir}$ variable differ across industries. Thus, the effects of input demand linkages on establishments' location in the BMR are dependent on industry. In motor vehicle and textile industries, the effects are generally negative. This indicates that in these two industries, establishments located in the BMR are more vertically integrated than establishments located elsewhere. However, in the food products and beverages industry, the coefficients turns out to be positive, suggesting that in this industry vertically disintegrated establishments tend to be located in the BMR. This is possibly because the BMR is known as the largest market in the country for both inputs and final products, so that purchases of raw materials and inputs can be easier in the BMR.

Third, in the motor vehicles industry, foreign-owned establishments are less likely than Thai-owned establishments to be located in the BMR. In fact, foreign-owned establishments are no longer concentrated in the BMR but concentrated in surrounding provinces, particularly Ayutthaya and three eastern seaboard provinces (Chon Buri, Chachoengsao, and Rayong).[65] These facts confirm the relocation of foreign-owned establishments from the highly-congested BMR to the less-congested provinces nearby.[66] However, in the food industry, foreign establishments still find the BMR more attractive as compared to other areas. In the textile industry, the coefficients are not statistically significant. Hence, it is not clear whether foreign textile establishments are more likely than Thai establishments to select the BMR as their location.

The coefficients of the EXP_{ir} variable are negative in all sectors, though insignificant

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[65] Out of total 157 foreign-owned motor vehicle establishments, 115 (73.2%) are located in Chon Buri (66), Chachoengsao (21), Rayong (6), and Ayutthaya (22) (Author's compilation from industrial census 2007).
[66] In the electronics industry, Kittiprapas and McCann (1999) also find that as firms' FDI share increases, the probability that electronics firms will locate in Bangkok decreases, and the probability that they will locate in neighboring provinces increases. This means that foreign firms prefer neighboring provinces to Bangkok city.

in some cases. These results run counter to our expectation that export-oriented establishments would prefer a large agglomeration area where they can benefit from spillovers of export-related information (Becchetti and Rossi 2000; Greenaway and Kneller 2008; Antonietti and Cainelli 2009). It is obvious from our results that export-oriented establishments no longer use the BMR as a production site for export. Further investigation found that the negative coefficients for EXP_{ir} come about because the presence of export establishments in the BMR is relatively small in comparison to non-export establishments. In other words, the BMR is more important as a production site for domestic markets than for export. For example, in the motor vehicle industry, the number of export establishments account for only 18.6% of all motor vehicle establishments in the BMR, while the number of non-export establishments account for 81.4%. While the majority of motor vehicle establishments in the BMR are non-exporters, the majority of motor vehicle establishments in Chon Buri, Chachoengsao, Rayong, and Ayutthaya are exporters. In Chon Buri, Chachoengsao, Rayong, and Ayutthaya, the number of export establishments account for 61.9%, while the number of non-export establishments account for only 38.1%. This information indicates that the BMR has lost its relative importance as an export-oriented production site to these four provinces.[67] Another interpretation is that information on exports and export facilities are also available in other areas outside the BMR, especially in such provinces as Chon Buri, Chachoengsao, and Rayong which are covered by the ESB scheme (Lecler 2002; Techakanont 2008).[68]

The coefficients of $INDEP_{ir}$ vary across industries. In the food products and beverage

[67]Unfortunately, the data on export values at the establishment level are not available. Therefore, we cannot compare motor vehicle establishments in the BMR with those in Chon Buri, Chachoengsao, Rayong, and Ayutthaya in terms of export values or export share.

[68] Out of 284 export establishments in motor vehicle sector, 167 establishments (59%) are located in Chon Buri, Chachoengsao, Rayong, and Ayutthaya, while 102 establishments (36%) are located in the BMR (Author's compilation from industrial census 2007).

industry, the coefficients tend to be positive, which suggests that the likelihood that independent establishments in this industry will be located in the BMR is greater than for branches or subsidiaries. In the motor vehicle and textile industries, the coefficients of this variable are not statistically significant at the acceptable level. Thus, I conclude that in the motor vehicles and textiles industries it is not clear whether independent establishments are more likely than branches and subsidiaries to be located in the BMR.

The last establishment-level variable is $SKILL_{ir}$, which is a proxy for the skilled labor utilization of establishments. The results for all three sectors show that the effects of skilled labor utilization on an establishment's decision to be located in the BMR are positive. This means than establishments with a higher share of skilled workers are more likely than those with a smaller share of skilled workers to be located in the BMR. This is consistent with the notion that more highly skilled establishments tend to be more efficient and thus are less sensitive to high wages in the agglomerated regions than their counterpart lower skilled establishments (Blanchflower and Oswald 1994; Kittiprapas and McCann 1999). My finding is consistent with that of Kittiprapas and McCann (1999), which studied the location of electronics establishments in Thailand and found that establishments located in the BMR are more likely to be establishments with a high proportion of skilled workers. According to Kittiprapas and McCann (1999), peripheral areas are dominated by establishments employing a relatively low-skilled and low-wage workforce and carrying out the types of routine activities which do not require the localized information spillovers and specialized labor inputs.

Table 4.9: Binary logistic regression results for the motor vehicle industry (BMR location)

	(1)		(2)		(3)		(4)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	0.14(0.36)	1.15	-17.9(0.20) [a]	1.6E-08	-10.5(1.05) [a]	2.7E-05	-18.1(2.06) [a]	1.4E-08
$SIZE_{ir}$	0.37(0.07) [a]	1.44	-	-	0.13(0.07) [c]	1.13	0.29(0.07) [a]	1.33
$INPUT_{ir}$	-1.08(0.27) [a]	0.34	-	-	-0.94(0.38) [b]	0.39	-0.91(0.33) [a]	0.40
FOR_{ir}	-2.01(0.26) [a]	0.13	-	-	-1.82(0.33) [a]	0.16	-1.88(0.29) [a]	0.15
EXP_{ir}	-0.99(0.20) [a]	0.37	-	-	-1.21(0.27) [a]	0.30	-1.32(0.25) [a]	0.27
$INDEP_{ir}$	0.21(0.21)	1.23	-	-	-0.24(0.28)	0.79	0.16(0.25)	1.17
$SKILL_{ir}$	0.12(0.23)	1.26	-	-	0.76(0.34) [b]	0.47	0.16(0.29)	1.17
RES_r	-	-	-1.96(1.57) [a]	0.14	-	-	-1.86(0.22) [a]	0.16
LAB_r	-	-	15.01(0.21) [a]	3.3E+06	-	-	2.49(0.19) [a]	12.09
$SKWF_r$	-	-	0.80(0.18) [a]	2.22	-	-	17.21(1.73) [a]	2.9E+07
$AG96_r$	-	-	-	-	3.06(0.25) [b]	21.41	-	-
IE_r	-	-	2.58(1.87) [a]	13.24	-	-	1.04(0.23) [a]	2.83
-2Log-Likelihood	1213[a]		931[a]		611[a]		805[a]	
R^2*(Cox & Snell)*	0.17		0.37		0.54		0.44	
# Obs.	1,007		1,007		1,007		1,007	

Note: [a], [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Author's estimation

Table 4.10: Binary logistic regression results for the food products and beverages industry (BMR location)

	(1)		(2)		(3)		(4)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	-3.92(0.14) [a]	0.02	-25.0(0.60) [a]	1.30E-11	-10.4(0.41) [a]	0.00	-11.2(1.82) [a]	1.30E-05
$SIZE_{ir}$	0.61(0.02) [a]	1.85	0.40(0.03) [a]	1.49	0.54(0.02) [a]	1.71	0.31(0.05) [a]	1.36
$INPUT_{ir}$	0.17(0.10) [c]	1.18	0.22(0.16)	1.24	0.17(0.10)[c]	1.19	0.07(0.27)	1.07
FOR_{ir}	0.25(0.31)	1.29	1.11(0.44) [a]	3.03	0.09(0.35)	1.09	1.32(0.69) [c]	3.76
EXP_{ir}	0.06(0.10)	1.06	-0.16(0.15)	0.85	-0.27(0.11) [a]	0.77	-0.80(0.21) [a]	0.45
$INDEP_{ir}$	0.28(0.09) [a]	1.32	0.04(0.14)	1.04	0.38(0.10) [a]	1.47	-0.31(0.21)	0.73
$SKILL_{ir}$	0.33(0.06) [a]	1.39	0.28(0.10) [a]	1.33	0.08(0.08)	1.08	-0.03(0.17)	0.98
RES_r	-	-	-	-	0.49(0.04) [a]	1.63	-	-
LAB_r	-	-	-	-	-	-	3.80(0.17) [a]	44.7
$SKWF_r$	-	-	-	-	12.1(0.45) [a]	1.7E+05	51.25(2.30) [a]	1.80E+22
$AG96_r$	-	-	4.65(0.12) [a]	1.00E+02	-	-	10.65(0.35) [a]	4.20E+04
IE_r	-	-	-	-	1.52(0.06) [a]	6.59	-	-
-2Log-Likelihood	11591[a]		4673[a]		9064 [a]		1851[a]	
R^2*(Cox & Snell)*	0.11		0.40		0.22		0.50	
# Obs.	16,416		16,416		16,451		16,451	

Note: [a], [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Author's estimation

Table 4.11: Binary logistic regression results for the textiles industry (BMR location)

BMR Location	(1)		(2)		(3)		(4)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	-3.65(0.23) [a]	0.03	-21.7(0.92) [a]	0.00	-14.8(0.81) [a]	0.00	-25.0(11.1) [a]	0.00
$SIZE_{ir}$	0.77(0.03) [a]	2.16	-	-	0.44(0.08) [a]	1.55	0.84(0.05) [a]	2.33
$INPUT_{ir}$	-0.47(0.14) [a]	0.63	-	-	-1.0(0.40) [a]	0.37	-0.59(0.22) [a]	0.55
FOR_{ir}	0.19(0.39)	1.21	-	-	0.70(0.60)	2.01	-0.85(0.50)	0.43
EXP_{ir}	0.23(0.15)	1.25	-	-	-0.42(0.41)	0.66	-1.23(0.22) [a]	0.29
$INDEP_{ir}$	-0.03(0.17)	0.97	-	-	-0.60(0.39)	0.55	0.19(0.23)	1.22
$SKILL_{ir}$	0.74(0.08) [a]	2.09	-	-	0.54(0.26) [b]	0.58	0.52(0.13) [a]	1.69
RES_r	-	-	0.62(0.11) [a]	1.85	-	-	0.33(0.12) [a]	1.38
LAB_r	-	-	0.84(0.09) [a]	2.32	-	-	1.10(0.10) [a]	3.01
$SKWF_r$	-	-	17.4(0.85) [a]	3.7E+07	-	-	20.5(10.0) [a]	7.9E+08
$AG96_r$	-	-	-	-	3.58(0.16) [a]	35.73	-	-
IE_r	-	-	2.84(0.12) [a]	17.06	-	-	2.85(0.14) [a]	1.7E+01
-2Log-Likelihood	5933[a]		3306[a]		800[a]		2741[a]	
R^2*(Cox & Snell)*	0.17		0.41		0.57		0.45	
# Obs.	7,839		7,839		7,839		7,839	

Note: [a], [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Author's estimation

The first province-level variable is RES_r. In the food products & beverages and textile industries, the coefficients of RES_r are positive and significant, suggesting that the likelihood that establishments in these two industries will be located in the BMR increases with the share of the resource-based sectors in the BMR's GPP. Conversely, in the motor vehicles industry the coefficients turn out to be negative and significant; thus, the probability that establishments in this sector will be located in the BMR decrease as the share of the resource-based sectors in the BMR's GPP increases.

The results of the two labor market variables – LAB_r and $SKWF_r$ – are as we expected. Both of them have positive and statistically significant coefficients for all examined industries; this suggests that a large labor pool and the availability of skilled labor are two main drivers of industrial agglomeration in the BMR. Thus, establishments are likely to be agglomerated in the BMR because this region offers them more advantages in terms of availability as well as quality of labor.

The degree of agglomeration in 1996 significantly explains the location of establishments in the BMR, as indicated by the positive and highly significant coefficients of variable $AG96_r$. This evidence supports Krugman's (1991a, 1991b) argument that establishments tend to select a location where there is a sufficiently large number of pre-existing establishments that can generate large market demand; by locating in such places, establishments can attain economies of scale. In fact, a previous study on factors contributing to industrial agglomeration in the BMR by Tsuji et al. (2008) also reveals similar findings. According to them, before 1986 large establishments came to the BMR and regarded this region as a production base. Those establishments developed the labor markets (especially high-quality labor) and generated information and technological spillovers in the BMR. Consequently, second-generation establishments entered the BMR and were followed by a number of smaller establishments which aimed to benefit from the large and developed the BMR markets (Ibid.). My evidence indicates that previous agglomeration matters: large industrial agglomeration in the BMR today is to a great extent determined by the level of agglomeration before.[69]

The last independent variable is the policy-related variable, i.e., the presence of industrial estate in the provinces (IE_r). The effects of this variable are positive and statistically significant in all three industrial sectors, which can be explained as meaning that the availability of infrastructure in the form of industrial estates is one of the main factors that attract establishments so that they will be located in the BMR. Positive effects of this variable imply that the development of modern infrastructures (such as industrial estates) in other regions may help generate agglomeration in those regions. Of course, this may largely depend on the quality of infrastructure and other incentives offered as well.

4.5.2 Establishments' location in the emerging clusters

Data exploration for the analysis of establishments' location in emerging clusters was performed in the same way as did for the BMR location analysis – checking for the presence of zero cells, complete separation, and high binary correlations among the pairs of independent variables. The results were generally similar to those of the BMR location analysis. The variable $AG96_r$ exhibits high correlations with other province-level variables. Therefore, I estimate them separately in order to avoid the multicollinearity problem. However, it is found that in the textile sector data the IE_r variable exhibits the zero-cell problem: none of the emerging clusters has an industrial estate. Hence, I exclude IE_r from the model specifications for the textile sector. The results of logistic regression for all three

[69] Fujita (2007) defines this phenomenon as *circular causation.*

sectors are presented in Tables 4.12 – 4.14. In each table, three model specifications (denoted by (1), (2), and (3)) are reported: the first specification includes establishment-level variables only; the second specification includes establishment-level variables and $AG96_r$; and the last specification includes both establishment-level and province-level variables (with $AG96_r$ excluded due to its high correlations with other province-level variables). I discuss the results by industry as follows.

a. Motor vehicles

As shown in Section 4.4, the motor vehicle industry exhibits a spatial pattern which is different from the food product and beverage industry and the textile industry. In the motor vehicle industry, establishments had begun to be agglomerated in the BMR first and then moved to such provinces as Chon Buri, Chachoengsao, Rayong, and Ayutthaya, which are the provinces adjacent to the BMR. In other words, the motor vehicle cluster has expanded from the BMR to these four provinces. Based on this phenomenon, it is possible to treat the BMR and these four provinces as the same region and analyze the factors that influence motor vehicle establishments to be located in this region. However, although such analysis has an advantage in terms of taking into account the entire spatial scope of agglomeration, it also has some limitations: by treating the BMR and the four provinces as the same region, we cannot examine the factors influencing the relocation of the motor vehicle industry. As observed from Section 4.5, the degree of motor vehicle industry agglomeration in the BMR has significantly dropped between 1996 and 2006, while the degrees of agglomeration in Chon Buri, Chachongsao, Rayong, and Ayutthaya have increased remarkably in the same period (see Figure 4.1). This indicates that industrial relocation from the BMR to these four provinces has occurred in this period. In order to examine why these four provinces have attracted motor vehicle establishments, we need to treat them as a separate region aside from the BMR. Therefore, in this analysis, I treat Chon Buri, Chachongsao, Rayong, and Ayutthaya as emerging clusters, as different from the BMR, which is treated as an established cluster.[70] Nevertheless, in order to take into account the entire scope of spatial agglomeration, I also supplement the analysis that treats the BMR and these four provinces as the same industrial cluster. The results of this analysis are provided in Appendix 5.4 and are interpreted later in this section.

Table 4.12 shows the factors that affect motor vehicle establishments' location in the emerging clusters (Chon Buri, Chachoengsao, Rayong, and Ayutthaya). In the motor vehicle industry, some characteristics of establishments located in these provinces are the reverse of those in the BMR. Highly vertically integrated establishments, foreign-owned establishments, and export establishments are more likely to be located in these four provinces than in the BMR. As modern export infrastructure (e.g., export clearance units, deep seaports) is available in the Eastern Seaboard area, export establishments find it more beneficial to locate their production in this area than in the BMR. As this area is close to the BMR, export establishments can still utilize the export-related services and export information available in the BMR. Note that foreign establishments tend to benefit disproportionately in this case because most of them export. [71] Thus, foreign-owned establishments tend to favor this area

[70] As noted earlier in this chapter, these four provinces can be treated as emerging clusters for serveral reasons. First, the degree of agglomeration (measured by establishment density) in these provinces, though it increased between 1996 and 2006, is not yet equal to that of the BMR. Second, we can still observe the relocation of motor vehicle establishments to these four provinces during the same period. This means that it is still possible that these provinces will exhibit a degree of agglomeration equal to the BMR which has become a mature cluster since the late 1990s, as can be observed from the large drop in the number of motor vehicle establishments in this region. In fact, in the study of the electronic firms' location by Kittiprapas and McCann (1999), the BMR is treated separately from other regions (including the ESB provinces such as Chon Buri, Chachoengsao, and Rayong) with the purpose of investigating the determinants of firm location in each region.

[71] Out of 157 foreign-owned establishments in the motor vehicles industry, 133 establishments (85%) export their products. On the other hand, out of 850 Thai-owned establishments in this industry, only 151 establishments (18%) export their products (Author's compilation from industrial census 2007).

more than the BMR.

In general, large establishments tend to be located in these four provinces. In the previous results we have found that motor vehicle establishments in the BMR tend to be larger when compared to establishments in the whole country. However, when particularly compared with motor vehicles in these four provinces, establishments in the BMR tend to be smaller. This indicates that, by being located in these four provinces, motor vehicle establishments can attain economies of scale; and this may be one of the reasons why motor vehicle establishments are attracted to these provinces.

In terms of skilled labor utilization, motor vehicle establishments in these four provinces are likely to employ a number of skilled workers. They even have a larger share of skilled workers than establishments in the BMR (note that the coefficients of $SKILL_{ir}$ are always positive, though with a weak statistical significance level).

At the provincial level, it is found that the share of skilled workforce ($SKWF_r$) and the presence of industrial estates (IE_r) tend to work as pull factors that attract motor vehicle establishments to Chon Buri, Chachoengsao, Rayong, and Ayutthaya. This finding is consistent with that of Lecler (2002) and Techakanont (2008) which find that availability of skilled workers and high-quality infrastructure (e.g. seaport, road networks, and industrial estates) are among the key factors explaining the relocation of motor vehicle establishments from the BMR to such nearby provinces as Chon Buri, Chachoengsao and Rayong.[72]

The previous level of motor vehicle agglomeration ($AG96_r$) in these provinces tends to play a less important role in attracting motor vehicle establishments. The negative effect of $AG96_r$ runs counter to our expectation. However, this is not impossible if we consider that these four provinces are very close to the BMR so that the agglomeration in the BMR may

[72] Other relevant factors are the proximity to the BMR and the investment incentives provided by the BOI (see Lecler 2002 and Techakanont 2008).

have some influence on establishments' decision to locate in these four provinces. When we treat Chon Buri, Chachoengsao, Rayong, and Ayutthaya as an extended part of industrial cluster (i.e., treating the BMR and Chon Buri, Chachoengsao, Rayong, and Ayutthaya as the same region), we can find that the effect of $AG96_r$ become positive and statistically significant (Appendix 5.4). We can interpret this result that the previous level of motor vehicle agglomeration in the BMR influences motor vehicle establishments' decision to be located in Chon Buri, Chachoengsao, Rayong, and Ayutthaya. In fact, the previous studies (Lecler 2002; Techakanont 2008) also show that input supply networks have been established among automobile firms located in the BMR and those located in these four provinces. Therefore, by being located in the provinces contiguous with the BMR (as in the cases of Chon Buri, Chachoengsao, Rayong, and Ayutthaya), establishments can enjoy the increased demand for inputs from establishments agglomerated in the BMR.

In addition, when we treat the BMR and Chon Buri, Chachoengsao, Rayong, and Ayutthaya as the same industrial cluster (results in Appendix 5.4), most variables have coefficients that are consistent with our expectation. Motor vehicle establishments located in the cluster tend to be large, foreign-owned, export-oriented establishments which use more skilled labor. The regional factors that attract establishments to be located in the industrial cluster include: (1) large labor pool; (2) availability of skilled labor; (3) well-developed infrastructure (in terms of industrial estates); and (4) previous agglomeration of motor vehicle establishments.

b. Food products and beverages[73]

In the food products and beverages industry, establishments in the emerging clusters have many characteristics that are opposite to those in the BMR. They tend to be smaller, Thai-owned, and domestic market-oriented establishments and demand less skilled labor, as evidenced by the negative coefficients of $SIZE_{ir}$, FOR_{ir}, EXP_{ir}, and $SKILL_{ir}$, respectively. As establishments in the emerging clusters are mostly young establishments begun after 1996, they tend to be smaller than those in the BMR which were established long before.

The location of establishments in the emerging clusters, to some extent, defines their markets. Establishments in the emerging clusters are more likely to sell their products within the province where they are located or to other provinces in Thailand, but less likely to sell to foreign markets as compared to establishments in the BMR. Additionally, while food and beverage establishments in the BMR tend to employ more skilled workers, establishments in the emerging clusters tend to employ unskilled workers which are generally cheaper than skilled ones.

At the provincial level, the abundance of labor force, availability of skilled labor, agglomeration economies, and industrial estate infrastructures do not seem to be the real advantages which attract foods and beverage establishments to be located in the emerging clusters. The only examined factor which is statistically significant in attracting establishments to the emerging clusters is agricultural production. As can be seen in Table 4.13, the coefficient of RES_r, which captures GPP from resource-based sectors such as agriculture and fishery, is positive and significant at the 5% level. This indicates that the raw materials and inputs needed for food production are the primary concern of establishments in

[73] In the food products and beverage industry, emerging clusters include Ayutthaya, Ang Thong, Chon Buri, Ratchaburi, Samut Songkram, Sing Buri, Chai Nat, Suphan Buri, Khon Kaen, Maha Sarakham, Amnat Charoen, Kalasin, Mukdahan, Lamphun, Phrae, Phayao, Chiang Rai, Songkhla, Satun, Trang, Phatthalung, Pattani, Narathiwat

food products and beverage industry in deciding to be located in the emerging clusters.

c. Textiles[74]

Table 4.14 presents logistic regression models estimating textile establishments' decision to be located in the emerging clusters. Textile establishments in the emerging clusters tend be smaller, Thai-owned, domestic-oriented and use less skilled labor. Similar to food and beverage establishments, textile establishments in the emerging clusters tend to be younger establishments founded after 1996; thus, they are likely to be smaller than textile establishments in the BMR which were established long before. Another important aspect of textile establishments in the emerging clusters is that they tend to be less vertically integrated, as evidenced by the positive and significant coefficients of the $INPUT_{ir}$ variable. Thus, it is likely that the textile industrial structure in the emerging clusters allows for outsourcing and subcontracting among establishments to take place.

It is obvious that textile establishments that have been established in the emerging clusters are those utilizing the cheap labor. Note that wages in these provinces are much cheaper than wages in the BMR. The skilled labor utilization of establishments located in the emerging clusters is also relatively low compared with those in the BMR. Thus, the emerging clusters tend to exhibit the agglomeration of small and less efficient textile establishments employing less skilled labor and cheaper workers.

For provincial level variables, it is found that the coefficients of LAB_r and $SKWF_r$ are negative and significant. As the variable $SKWF_r$ (i.e., the share of working population with tertiary education) may somehow capture the wage of workers in the province, the negative coefficient of $SKWF_r$ can mean that the probability that textile establishments will be located

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[74] In the textile industry, emerging clusters include Roi Et, Si Sa Ket, Khon Kaen, Surin, Maha Sarakham, Ubon Ratchathani, Kalasin, Nong Bua Lam Phu, Buri Rum, Yasothon, Amnat Charoen, Chiang Rai, Phayao, Chiang Mai.

in the emerging clusters decreases as the wages increase (as a result of the increase in the proportion of the population which is highly educated). Thus, this implies that the abundance of labor supply is not as important as the costs of labor in attracting textile establishments to the emerging clusters. This is consistent with the finding that textile establishments in those provinces tend to employ unskilled workers.

Table 4.12: Binary logistic regression results for the motor vehicles industry (Emerging clusters)

	(1)		(2)		(3)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	-3.0(0.32) [a]	0.05	-2.6(0.33) [a]	0.07	39.9(6.2) [a]	2.135E+17
$SIZE_{ir}$	0.81(0.21) [a]	2.25	0.85(0.21) [a]	2.33	0.94(0.27) [a]	2.55
$INPUT_{ir}$	0.40(0.20) [b]	1.49	0.37(0.20) [c]	1.45	0.09(0.25)	1.09
FOR_{ir}	1.70(0.24) [a]	5.47	1.68(0.24) [a]	5.38	1.37(0.31) [a]	3.92
EXP_{ir}	1.12(0.21) [a]	3.07	1.17(0.21) [a]	3.21	1.11(0.27) [a]	3.04
$INDEP_{ir}$	0.31(0.23)	1.36	0.33(0.23)	1.39	0.10(0.28)	1.10
$SKILL_{ir}$	0.22(0.19)	1.24	0.23(0.19)	1.26	0.40(0.24) [c]	1.45
RES_r	-	-	-	-	4.63(0.47) [a]	1.03E+02
LAB_r	-	-	-	-	-6.89(0.79) [a]	1.00E-03
$SKWF_r$	-	-	-	-	15.9(3.22) [a]	8.10E+06
$AG96_r$	-	-	-0.64(0.18) [a]	0.53	-	-
IE_r	-	-	-	-	20.22(24.8)	6.03E+08
-2Log-Likelihood	848 [a]		835 [a]		543 [a]	
R^2 *(Cox & Snell)*	0.24		0.52		0.44	
# Obs.	799		799		799	

Notes: (1) Emerging clusters include Chon Buri, Chachoengsao, Rayong, and Ayutthaya; (2) [a] , [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively. *Source*: Author's estimation

Table 4.13: Binary logistic regression results for the food products and beverages industry (Emerging clusters)

	(1)		(2)		(3)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	3.18(0.11) [a]	24.13	23.33(0.62) [a]	1.35E10	17.51(0.60) [a]	4.0E+07
$SIZE_{ir}$	-0.58(0.02) [a]	0.56	-0.41(0.03) [a]	0.66	-0.58(0.03) [a]	0.56
$INPUT_{ir}$	-0.10(0.11)	0.90	-0.23(0.16)	0.79	-0.22(0.13)	0.80
FOR_{ir}	-0.24(0.36)	0.79	-0.99(0.44) [b]	0.37	0.39(0.41)	1.48
EXP_{ir}	-0.23(0.11) [b]	0.79	0.11(0.15)	1.12	0.11(0.12)	1.11
$INDEP_{ir}$	-0.14(0.10)	0.87	-0.05(0.14)	0.96	-0.41(0.12) [a]	0.66
$SKILL_{ir}$	-0.48(0.07) [a]	0.62	-0.28(0.10) [a]	0.76	-0.11(0.08)	0.90
RES_r	-	-	-	-	0.04(0.02) [b]	1.04
LAB_r	-	-	-	-	-0.92(0.06) [a]	4.0E-01
$SKWF_r$	-	-	-	-	-13.3(0.52) [a]	0.00
$AG96_r$	-	-	-4.31(0.12) [a]	0.01	-	-
IE_r	-	-	-	-	-1.58(7) [a]	0.206
-2Log-Likelihood	9554[a]		4585[a]		7141[a]	
R^2*(Cox & Snell)*	0.12		0.45		0.30	
# Obs.	10,438		10,438		10,438	

Notes: (1) Emerging clusters include Ayutthaya, Ang Thong, Chon Buri, Ratchaburi, Samut Songkram, Sing Buri, Chai Nat, Suphan Buri, Khon Kaen, Maha Sarakham, Amnat Charoen, Kalasin, Mukdahan, Lamphun, Phrae, Phayao, Chiang Rai, Songkhla, Satun, Trang, Phatthalung, Pattani, Narathiwat; (2) [a] , [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively. *Source*: Author's estimation

Table 4.14: Binary logistic regression results for the textiles industry (Emerging clusters)

	(1)		(2)		(3)	
	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	2.11(0.31) [a]	8.21	13.3(0.85)[a]	5.98E+05	21.3(1.10) [a]	1.78E+09
$SIZE_{ir}$	-0.79(0.04) [a]	0.45	-0.61(0.10)[a]	0.54	-1.08(0.06) [a]	0.34
$INPUT_{ir}$	0.54(0.15) [a]	1.71	1.19(0.41)[a]	3.28	0.73(0.21) [a]	2.08
FOR_{ir}	-2.37(1.13) [b]	0.09	-1.79(1.19)	0.17	0.17(1.26)	1.18
EXP_{ir}	-1.15(0.23) [a]	0.32	0.24(0.55)	1.27	0.09(0.30)	1.09
$INDEP_{ir}$	1.16(0.25) [a]	3.20	0.96(0.49)[a]	2.60	1.00(0.32) [a]	2.72
$SKILL_{ir}$	-0.76(0.08) [a]	0.47	-0.86(0.28)[a]	0.42	-1.03(0.13) [a]	0.35
RES_r	-	-	-	-	-4.46(0.18) [a]	0.01
LAB_r	-	-	-	-	-0.98(0.07) [a]	0.38
$SKWF_r$	-	-	-	-	-50.3(2.20) [a]	0.00
$AG96_r$	-	-	-3.29(0.16)[a]	0.04	-	-
IE_r	Exd.	Exd.	Exd.	Exd.	Exd.	Exd.
-2Log-Likelihood	4677[a]		734[a]		2613[a]	
R^2*(Cox & Snell)*	0.23		0.65		0.49	
# Obs.	5,087		5,087		5,087	

Notes: (1) Emerging clusters include Roi Et, Si Sa Ket, Khon Kaen, Surin, Maha Sarakham, Ubon Ratchathani, Kalasin, Nong Bua Lam Phu, Buri Rum, Yasothon, Amnat Charoen, Chiang Rai, Phayao, Chiang Mai; (2) Exd. = variable is excluded due to the complete separation problem; (3) [a] , [b] and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively. *Source*: Author's estimation

4.6 Conclusion

This chapter examined the determinants of spatial clustering of Thai manufacturing industries based on the perspective of establishments' location choices. I selected three industries (motor vehicles, food products and beverages, and textiles) as case studies to indentify the patterns of spatial clustering. The method used to identify the industrial cluster is establishment density, which measures the extent to which establishments are agglomerated in each province relative to the provincial area size. The Bangkok Metropolitan Region (BMR), which is regarded by previous studies as an industrial cluster, is also regarded in this study as an industrial cluster. Thus, the level of establishment density in the BMR is used as the threshold to identify industrial clusters in other provinces. The results have revealed that the BMR is still the main industrial cluster in the country for all three industries. However, in all three industries, there exist emerging clusters which are defined by this study as the provinces which exhibit a trend toward the formation of industrial clusters due to a large increase in the number of establishments between 1996 and 2006.

Based on this information, I developed two establishment location models: the first model explains the determinants of establishments' decision to be located in the BMR which is an industrial cluster, and the second model explains the determinants of establishments' decision to be located in the emerging clusters. While the first model analyzes the existence of the industrial cluster, the second model analyzes the formation of industrial clusters (i.e., the movement of provincial industries toward becoming industrial clusters). These two establishment location models take establishment and provincial characteristics as key independent variables. Binary logistic regression is employed in the analysis.

In the analysis of establishments' location in the BMR, the results from logistic regression reveal that establishment size and skilled labor utilization are the only two variables which are universally positive and have significant effects on establishments' decision to be located in the BMR. The effects of other variables vary across industries. For province-level variables, I have found that the number of the work force and quality of workers, the level of previous agglomeration, and the presence of industrial estates are key drivers of industrial clustering in the BMR. Thus, it is likely that establishments have decided to be located in the BMR because of the benefits they would gain in terms of a large labor pool, availability of skilled labor, large market demands, and well-developed infrastructure.

In the analysis of establishments' location in the emerging clusters, each industry reveals different factors determining establishments' location in the emerging clusters. First, for the motor vehicles industry, I analyzed the location of establishments in Chon Buri, Chachoengsao, Rayong, and Ayutthaya, which can be treated as an extended part of the motor vehicle industrial cluster from the BMR. However, this study treats these four provinces as emerging clusters separately from the BMR in order to specifically examine why a large number of motor vehicle establishments have been founded in these four provinces in recent years. The results reveal that large, foreign-owned, export oriented, and high skill demanding establishments are more inclined to be located in these four provinces. It is found that such factors as availability of skilled workers and a developed infrastructure are key factors determining motor vehicle establishments to be located in these provinces.

Supplementary analysis was conducted by treating Chon Buri, Chachoengsao, Rayong, Ayutthaya, and the BMR as the same cluster. It is found that motor vehicle establishments located in this cluster tend to be large, foreign-owned, export-oriented establishments demanding more skilled labor. The regional factors that attract establishments to be located in the industrial cluster include: (1) large labor pool; (2) availability of skilled labor; (3) well-developed infrastructure (in terms of industrial estates); and (4) previous agglomeration of motor vehicle establishments. Overall, this finding is as we expected.

Second, for the food products and beverages industry, establishments attracted to the emerging clusters tend to be small, Thai-owned, domestic market-oriented, and less skill demanding establishments. The most important factor that determines the location of food and beverage establishments in the emerging clusters is the provincial share of the resource-based sector in the gross provincial product (GPP). This indicates that the formation of the food and beverage cluster in a particular province is much dependent on the resources available in the province that can be used as inputs and raw materials for the food and beverage industry.

Third, for the textile industry, it is found that establishments that are attracted to the emerging clusters are small, Thai-owned, domestic-oriented, and less skill demanding establishments. Additionally, the location of textile establishments in the emerging clusters is explained by the availability of cheap labor. With the availability of cheap labor, many textile establishments have recently relocated to or started up in provinces in the Northeast (e.g., Roi Et, Khon Kaen, Maha Sarakham, and Kalasin) and in the North (e.g., Chiang Rai, Phayao, and Chiang Mai). As a result, the textile industry in those provinces has moved toward becoming industrial clusters.

Before ending this chapter, I note that the empirical results presented in this chapter are rather consistent with the argument made by Fujita (2007) that knowledge-based and machinery establishments are more likely than resource-based or labor-intensive ones to concentrate in a large agglomeration area. High-technology or knowledge-based sectors (e.g. automobile, electronics and software industries) are less sensitive to such dispersion forces as increased land prices and high labor costs. These sectors need to be located in large urban areas in order to benefit more from knowledge spillovers.

As we have seen, the BMR and four neighboring provinces (i.e., Ayutthaya, Chon

Buri, Chachoengsao, and Rayong) are still the main production site for the motor vehicle industry. So far, this industry has not shown a significant trend toward a rapid industrial decentralization, such as we have observed in food and textile industries. Moreover, the motor vehicle industry tends to be sensitive to such factors as scale economies, import-export facilities, a skilled workforce, and agglomeration economies; this is consistent with Fujita's (2007) argument.

Chapter 5

Industrial Clustering and Manufacturing Establishment's Productivity

5.1 Introduction

The aim of this chapter is to answer the second main research question: what are the effects of industrial clustering on manufacturing establishments' performance? In order to address this question, I take the labor productivity of manufacturing establishments as an indicator of performance because: (1) as labor productivity is a widely used indicator of firms' performance in previous studies on the effects of agglomeration economies,[75] by using labor productivity it is possible to compare the results from my analysis with those from the previous studies; and (2) a measure of labor productivity is directly available in the Thai manufacturing industry census data set. Thus, the specific question to be addressed in this chapter is: does industrial clustering generate higher labor productivity of manufacturing establishments? I apply regression analysis to answer this question.

The relationship between geographic clustering of firms and productivity improvement is a fundamental issue in industrial agglomeration literature. This issue has been subject to theoretical discussion and empirical investigation over three decades. Empirical evidence about the effects of agglomeration economies on productivity from various countries

[75] Empirical studies which examine a direct relationship between agglomeration and productivity are Sveikauskas (1975), Segal (1976), Moomaw (1981), Ciccone and Hall (1996), Capello (1999), Ciccone (2002), Rigby and Essletzbichler (2002), Henderson (2003), Madsen et al. (2003), Cingano and Schivardi (2004), Koo (2005), Liu et al. (2005), Baldwin et al. (2008), Cainelli (2008), and Brown and Rigby (2009). In some other studies, due to the lack of reliable data to directly measure productivity, productivity is proxied by such indicators as employment growth (Glaeser et al. 1992; Henderson et al. 1995), wage premium or wage growth (Glaeser and Mare 2001; Wheaton and Lewis 2002; Glaeser and Resseger 2009), or new-enterprise startups (Rosenthal and Strange 2003), assuming that productivity is related with those proxies (i.e. higher productive regions (firms) tend to exhibit higher employment, wage, and start-up rate than less productive regions (firms)).

has been increasingly added to the body of literature. [76] However, despite such richness in the body of literature, there are still some controversial and debated issues. First, there exists a long-standing theoretical debate about the effects of localization economies *versus* urbanization economies, and empirical studies still provide contrasting evidence on this issue (Panne 2004; Rosenthal and Strange 2004). Second, while the notion that agglomeration economies generate productivity growth is widely accepted, the knowledge about spatial and industrial scopes in which agglomeration economies take place is not yet well established. Until recently, researchers have made little effort to examine the effects of agglomeration economies at different spatial and industrial scopes in order to find the scope at which the effects of agglomeration economies on productivity are most vigorous.[77]

In this chapter, I take these issues into consideration. First, although the definition of industrial cluster used in this study is in line with the localization economies concept (i.e. *spatial agglomeration of firms in the same industry*), the productivity effects of urbanization economies are also investigated. Specifically, I test the effects of these two types of agglomeration economies separately to see which form of agglomeration is conducive to the increase in establishments' labor productivity. Second, taking the issue of spatial and sectoral scopes into account, I examine the effects of industrial clustering on establishments' labor productivity at different industrial and spatial units. This is to find whether different spatial and sectoral scopes of clustering have different effects on establishments' labor productivity.

This chapter is structured as follows. Section 5.2 presents some theoretical models used for analyzing the relationships between industrial clustering and labor productivity, and discusses some hypotheses based on theoretical and empirical literature. Section 5.3 provides

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[76] See Rosenthal and Strange (2004) for a comprehensive literature review.

[77] Notable studies in this area include Rosenthal and Strange (2003), Baldwin et al. (2008), Brown and Rigby (2009).

some discussions on data and variable construction. Section 5.4 discusses relevant methodological issues. Section 5.4 presents and discusses the results of regression analysis. Finally, Section 5.5 concludes the chapter.

5.2 Model and hypotheses

To estimate the effects of industrial clustering on the labor productivity of manufacturing establishments, I begin with a standard production function:

$$Y_{ijr} = A_{ijr} K_{ijr}^{\alpha} L_{ijr}^{\beta} \qquad (1)$$

where Y_{ijr}, K_{ijr} , and L_{ijr} are, respectively, value-added, capital stock, and labor force of manufacturing establishment *i* embedded in industry *j* and region *r*. The term A_{ijr} denotes the state of technology of the establishment, which is assumed to be influenced by agglomeration economies (i.e. localization and urbanization economies) as well as establishment-specific characteristics (Henderson 2003; Moretti 2004; Martin et al. 2008) and can be modeled as:

$$A_{ijr} = (LE)_{jr}^{\gamma} (UE)_{r}^{\delta} X_{ijr}^{\lambda} \qquad (2)$$

where LE_{jr} is localization economies generated from the agglomeration of industry *j* in region *r*; UE_r is urbanization economies generated from the agglomeration of all industries in region *r*; X_{ijr} denotes a set of factors which may influence the establishment's state of technology (X_{ijr} can be thought of in terms of establishment's specific assets such as its participation in international trade, foreign investment, and investment in research and development). Thus, equation (2) assumes that establishment *i*'s state of technology not only depends on its specific assets, X_{ijr}, but also on its immediate environment in terms of localization and urbanization economies (Martin et al. 2008). Obviously, the equation assumes that productivity effects of industrial clustering are generated from two sources – clustering of establishments in the same industry and clustering of establishments in different industries.

Next, we can divide equation (1) by L_{ijr} to give a labor productivity function:

$$y_{ijr} = \frac{Y_{ijr}}{L_{ijr}} = A_{ijr}K_{ijr}^{\alpha}L_{ijr}^{\beta-1} \tag{3}$$

where the lower case y_{ijr} denotes establishment *i*'s value-added per employee which is a measure of labor productivity used in this study.

To specify a testable econometric model, equations (2) and (3) are transformed into a linear function using natural logarithm. This process results in the following equations:

$$ln\, A_{ijr} = \gamma lnLE_{jr} + \delta lnUE_{r} + \lambda \boldsymbol{x}_{ijr} \tag{4}$$

and

$$ln\, y_{ijr} = ln\, A_{ijr} + \alpha ln\, K_{ijr} + (\beta\text{-}1)ln\, L_{ijr} \tag{5}$$

where lower case $\boldsymbol{x}_{ijr}$ denotes the log of X_{ijr} which is taken as control variables in this study. By substituting equation (5) into equation (4), an extended equation is produced as follows:

$$ln\, y_{ijr} = \alpha ln\, K_{ijr} + (\beta\text{-}1)ln\, L_{ijr} + \gamma lnLE_{jr} + \delta lnUE_{r} + \lambda \boldsymbol{x}_{ijr} \tag{6}$$

Equation (6) considers labor productivity of manufacturing establishments as a function of their capital investment, employment of labor, and other establishment-specific assets as well as localization and urbanization economies generated from, respectively, their co-location with other establishments in the *same* industry and their co-location with other establishments from *different* industries. I will now provide some theoretical discussion and draw hypotheses regarding the productivity effects of localization and urbanization economies as well as control variables as follows.

How do we expect the coefficients of localization economies (γ) and urbanization economies (δ)? Regarding localization economies, it follows from Marshall's (1920) observation that productivity can be enhanced when sectorally related firms are spatially clustered. According to him, such clustering generates *pecuniary externalities* because specific goods and services provided by specialized suppliers and workers with specific skills are always available and can be acquired at relatively low costs. Additionally, knowledge and information spillovers can occur easily in clusters where firms undertake related activities or share some basic understanding of specific industrial production, which allows for the transfer of industrial specific knowledge. Moreover, the clustering of related firms can also facilitate face-to-face interactions, and thus allows for the transfer of tacit knowledge which cannot be easily transferred by codification methods (Lissoni 2001; Dahl and Pedersen 2004). The positive effects of localization economies are proven by some empirical studies such as Nakamura (1985) and Martin et al. (2008).[78] However, it can be argued that benefits from own-industry agglomeration may be offset by the costs associated with an increased competition between firms in the same sector. When sectorally related firms are clustered, the degree of competition for labor and inputs may increase because similar firms need similar production factors (Lall et al. 2004). Thus, as the own-industry agglomeration can generate both benefits and costs, it is possible to find both positive and negative effects of localization economies.

The urbanization economies thesis differs from that of localization economies as it sees the spatial agglomeration of firms from different industries as key to productivity enhancement (Panne 2004, p.595). The reason for this is that a city with diversified industrial structure can facilitate a transmission of knowledge and ideas across different lines of work.

[78] Nakamura (1985) uses cross-section data of Japanese cities in 1979 and estimates the effects of agglomeration economies on productivity. He shows that heavy industries receive more productivity benefits from localization economies than from urbanization economies. Recent work by Martin et al. (2008) uses French firm-level panel data to estimate the effects of localization economies (defined as the employment of neighboring firms in the same industry), controlling for unobserved firm, industry, and regional heterogeneities. They find that a 10% increase of employment in neighboring firms of the same industry increases a firm's productivity by approximately 0.4-0.5%.

Firms embedded in that environment can benefit from the exchanges of different information, knowledge, and ideas that are new to them and are vital for creativity, innovation, and productivity (Jacobs 1969). Some empirical studies show that urbanization economies are significant for productivity improvement, such as Sveikauskas (1975), Tabuchi (1986), Glaeser et al. (1992), Cicone and Hall (1996), and Tabuchi and Yoshida (1999).[79] However, it can be argued that as the city grows larger, the benefits from urbanization economies may be offset by the costs of agglomeration (e.g. increased wage rates, land rents, and commuting time) which may result in a decline in firms' productivity (Carlino 1979; Lall et al. 2004; Baldwin et al.2008). Thus, for the coefficient of urbanization economies, either positive or negative signs can be expected.

What can we expect about the effects of control variables, $\boldsymbol{x}_{ijr}$, on establishments' labor productivity? In this study, control variables include structural and establishment-specific factors, namely localized competition ($COMP_{jr}$), export (EXP_{ijr}), import (IMP_{ijr}), foreign investment (FDI_{ijr}), organizational structure ($SING_{ijr}$), and investment in research and development (RND_{ijr}).

The first control variable is localized competition ($COMP_{jr}$) (i.e. the degree of competition in regional industry). The effect of localized competition on firms' productivity is not yet clear and is still subject to on-going debates in both theoretical and empirical

[79] Sveikauskas (1975) uses population size as a measure for urbanization and finds that a doubling of population size is associated with a 5.98% increase in labor productivity. Tabuchi (1986) uses Japanese city data and finds a doubling of population density – a measure of urbanization – increases labor productivity by about 4.3%. Glaeser et al. (1992) intentionally test localization economies against urbanization economies and find that urban diversity, not specialization, encourages employment growth - a proxy for productivity growth. Cicone and Hall (1996) establish that the relationship between employment density and productivity does exist. They empirically show that a doubling of employment density increases average labor productivity by 6%. Tabuchi and Yoshida (1999) examine the effects of agglomeration economies on consumption and production sides, using Japanese city-based data in 1992. They find that doubling city size increases the nominal wage by approximately 10% and argue that such increase is associated with an increase in productivity.

literature. On one hand, some scholars (e.g., Arrow 1962; Romer 1986) argue that monopolistic structure of regional industry is necessary for technological improvement. They maintain that knowledge spillovers are non-rival market externalities whose positive effects (e.g., enhancing technological capabilities) overflow to neighboring firms through one firm's innovation. Lack of property rights protection for innovative activities and of appropriate compensation to the innovators will reduce a firm's incentives to innovate, and consequently will slow down technological development. This theory predicts that technological development in regional industry will be faster if local industrial structure exhibits monopolistic behavior because it allows firms to appropriate the economic value accruing from their innovative activities (Feldman and Audretsch 1999; Combes 2000). On the other hand, it is argued that local industrial competitive structure is more conducive to knowledge spillovers and technological development than is monopolistic structure (Jacobs 1969, 1984; Porter 1990). According to Porter (1990), firms embedded in a competitive environment are forced to innovate otherwise they will not be able to compete with their innovative neighbors. Fierce competition will lead to an improvement in existing technologies and to a rapid adoption of new technologies, which are necessary for industrial growth (Glaeser et al. 1992; Gao 2004). As the effect of localized competition can be either positive or negative, in this analysis, we can expect either a positive or negative effect of $COMP_{jr}$.

Some firm-specific characteristics are also relevant for productivity improvement. It is argued that export can improve a firm's productivity through a learning-by-exporting process: firms participating in the export market can learn from their international buyers as well as their competitors; consequently, knowledge flows from buyers and competitors help to improve the post-entry performance of export starters (Flyges and Wagner 2008; Aw and

Hwang 1995; Greenaway and Kneller 2004).[80] Imports can also help firms to improve their productivity because, by importing new intermediate products from foreign markets, firms can expand their domestic product scope through the introduction of new product varieties, which generates dynamic gains from trade (Goldberg et al. 2008). Furthermore, importing more advanced intermediate inputs allows firms to learn new technologies which, consequently, help enhance their technological capabilities (Vogel and Wagner 2008). Thus, in the current study, I expect that establishments that export (EXP_{ijr}) or import (IMP_{ijr}) will be more productive than those that do not.

Foreign direct investment (FDI) literature maintains that foreign ownership is a significant factor for technological progress and productivity growth (Caves 2007).[81] It argues that, in order to compete with local firms that have better knowledge and information about local markets, foreign firms rely on the so-called "proprietary assets" (i.e. superior managerial and technological capabilities) which are intangible and are more likely to be transferred efficiently through internalization and expansion abroad than through market mechanism. Foreign affiliates and subsidiaries are said to benefit from the transfer of these assets from their parent firms and thus are more likely than local firms to be more efficient (Benfratello and Sembenelli 2006). Empirical literature also notes the importance of technological advantages of parent firms as a key to the better performance of foreign affiliates (Siripaisalpipat and Hoshino 2000). Based on these arguments, therefore, it is possible to expect that establishments which have foreign investment (FDI_{ijr}) will be more productive

[80] See Wagner (2007) for a very extensive review of empirical literature on the relationship between export and firm-level productivity.
[81] Literature on FDI also suggests that foreign investment has spillover effects (Kohpaiboon 2006; Yokota 2008). According to this literature, FDI inflows bring new technologies and know-how to the host country and its technologies spill over to domestic firms through three channels: demonstration, linkages, and labor mobility (Kohpaiboon 2009). However, it is argued that vertical linkages of foreign and domestic firms are found to be the most efficient form of FDI technology spillovers (Rodriguez-Clare 1996; Javorcik 2004).

than those which do not have foreign investment.

Organizational structure of firms is another factor which may affect labor productivity. Establishments embedded in the multi-plant firm structure can benefit from knowledge spillovers circulated among establishments of a given firm (Martin et al, 2008). Learning from other establishments in the same firm structure can help them to enhance their technological capability (Henderson 2003). Thus, we can expect that productivity will be higher for such establishments categorized as branch, affiliated company, or subsidiary than those independent establishments. In other words, in the context of the current study, independent establishments ($INDEP_{ijr}$) are expected to be less productive than branch or affiliated companies.

It has been established that investment in research and development (R&D) by firms can help improve their productivity (Grilliches 1986). Economists believe that firms' own investment in R&D can directly enhance its technological capability in generating new knowledge, information, and products, and enhancing absorptive capacity (i.e. ability to identify, assimilate, and exploit knowledge from the environment) (Cohen and Levinthal 1989). Thus, we can expect that establishments that invest in R&D (RND_{ijr}) will register higher labor productivity than those that do not.

Finally, I include dummy variables for industrial category (IND_j) and for region (REG_r) in the equation. The inclusion of IND_j is to control for unobserved industrial effects which may influence an establishment's labor productivity (e.g. macro-economic policies on the industry, technological progress at the industrial level, and industry life-cycles). In the same way, REG_r is included in the equation to capture unobserved regional characteristics which may affect establishments' productivity (e.g. regional policies, infrastructure development, and resource endowment)

Combining all of the above variables, we can form a full econometric model to be tested as follows (theoretical expected sign of coefficient is in parenthesis):

$$\ln y_{ijr} = \alpha \ln K_{ijr} + (\beta\text{-}1)\ln L_{ijr} + \gamma \ln LE_{jr} + \delta \ln UE_r + \lambda_1 COMP_{jr} + \lambda_2 EXP_{ijr}$$
$$+ \lambda_3 IMP_{ijr} + \lambda_4 FDI_{ijr} + \lambda_5 INDEP_{ijr} + \lambda_6 RND_{ijr} + \pi_1 IND_j + \pi_2 REG_r + \varepsilon_{ijr} \quad (7)$$

where

$\ln y_{ijr}$ = Labor productivity of establishment *i* in industry *j* and region *r*

$\ln K_{ijr}$ = Fixed assets of establishment *i* in industry *j* and region *r*

$\ln L_{ijr}$ = Number of workers of establishment *i* in industry *j* and region *r*

$\ln LE_{jr}$(+/–) = Localization economies of industry *j* and region *r*

$\ln UE_r$(+/–) = Urbanization economies of region *r*

$COMP_{jr}$ (+/–) = Localized competition of industry *j* and region *r*

EXP_{ijr}(+) = Dummy for export for establishment *i* in industry *j* and region *r*

IMP_{jr}(+) = Dummy for import for establishment *i* in industry *j* and region *r*

FDI_{ijr} (+) = Dummy for foreign share in establishment *i* industry *j* and region *r*

$INDEP_{ijr}$ (–) = Dummy for independent establishment for establishment *i* industry *j* and region *r*

RND_{ijr} (+) = Dummy for establishment's laboratory unit for establishment *i* industry *j* and region *r*

IND_j = Dummies for industrial category (IND_j = 1 for industrial category *j* and 0 for other categories

REG_r = Dummy for region (REG_r = 1 for region *r* and 0 for other regions)

ε_{ijr} = A stochastic error term containing other factors which affect $\ln y_{ijr}$

5.3 Data and variable construction

5.3.1 Data source

The analysis in this chapter mainly relies on the industrial census 1997 and 2007, provided by the National Statistical Office of Thailand (NSO). These two data sets contain the population of establishments that existed in 1996 and 2006. The numbers of establishments in the 1997 and 2007 data sets are 32,489 and 73,931, respectively. The advantage of these data sets lies in the fact that they represent the population of manufacturing establishments of all sizes in both years. Thus, there is no problem of selection bias in favoring a particular group of establishments. However, to protect the confidentiality of private information, NSO does not provide names and addresses of manufacturing establishments. Thus, it is impossible to trace the presence of the same establishment in both years, which is important for conducting a sophisticated statistical analysis.[82] Having realized such limitation, I decided to use the cross-section analysis based on the 2007 data set. However, the 1997 data set is also utilized by selecting some variables and using them as instrumental variables in the two-stage least square regression (2SLS) (this is explained in section 5.4).

At the establishment level, some balance-sheet data (e.g., employment, capital, exports, sales, intermediate costs, and wage) is available. Information on establishment location at various regional levels (district, province, subregion, and region), industry classification (at 2-, 3-, and 4-digit levels), and establishment structure (foreign investment and legal status) is also accessible. This information is sufficient to construct variables of our interest. Based on these data, variables can be constructed as follows.

[82] With this limitation, we cannot organize the data into a panel data set and conduct statistical analysis to controls for firms' unobserved heterogeneity which is a common methodological problem in the productivity analysis at the firm level (see Combes et al. 2008a; Matin et al. 2008)

5.3.2 Variable construction

a. Dependent variable: *labor productivity*

The dependent variable is manufacturing establishment's labor productivity which is defined as the logarithm of establishment's value-added (in Thai baht) divided by the number of workers employed. Thus, lny_{ijr} is constructed as follows:

$$ln\, y_{ijr} = ln\left(\frac{(Value\ added)_{ijr}}{(Number\ of\ workers\ employed)_{ijr}}\right)$$

where value-added is calculated by taking the difference between establishment's sales and its intermediate costs (in Thai baht); and workers here refer to all fulltime workers who are employed in both production and non-production processes.

b. Localization economies variable

As discussed above, localization economies are theoretically defined as spatial agglomeration of manufacturing establishments operating in the same sector. Thus, for establishment *i* embedded in sector *j* and region *r*, the localization economies variable is defined as:

$$lnLE_{jr} = ln(EST_{jr})$$

where EST_{jr} denotes the number of establishments in sector *j* and region *r*. In particular, $lnLE_{jr}$ is constructed by taking natural logarithm of the number of manufacturing establishments operating in the same sector and located in the same region. Note that this variable is defined based on the concept of industrial clustering used in this study (see Chapter 1). $lnLE_{jr}$ is measured at the regional industry level.

c. Urbanization economies variable

To capture the diversity of industrial structure of a region – theoretical definition of urbanization economies – a Herfindahl Index (*HI*) is used, and is defined as follows:

$$HI_r = \sum_j \left(\frac{EST_{jr}}{EST_r}\right)^2$$

where EST_r is the number of manufacturing establishments (all sectors) in region r, and EST_{jr} is as previously defined. This index measures the degree to which industrial structure of region r is diversified. *HI* takes the continuous value between zero and one: "$HI = 0$" means that industrial structure of the region is perfectly diversified, while "$HI = 1$" means that industrial structure in the region is occupied by a single industry.

To interpret urbanization economies variable ($lnUE_r$) in terms of elasticity (as with localization economies variable), I take a natural logarithm of a reverse *HI* as follows:

$$lnUE_r = ln\left(\frac{1}{HI_r}\right)$$

$lnUE_r$ now is a continuous variable taking a value between zero and infinity (Martin et al. 2008). The degree of industrial diversity increases as the value of $lnUE_r$ increases. Unlike the localization economies variable, the urbanization economies variable is measured at the regional level. It signifies the extent to which *overall* industrial structure of region r is diversified.

As noted above, the effects of agglomeration may transmit across industrial and spatial scopes. Hence, it is essential to construct variables that capture agglomeration effects at various industrial and spatial scopes. To deal with this issue, I measure localization and urbanization variables at different spatial and sectoral scopes. For spatial scope, province and subregion are taken as measurement units. The province is an administrative entity. Our data set contain all 76 provinces in Thailand.[83] The subregion is a group of contiguous provinces

[83] By mid-2010, the new 77th province was established by the Thai government. But the 2007 industrial census data covers the number of provinces existing at that time.

which is classified by the National Economic and Social Development Board (NESDB).[84] Based on this classification, there are 18 subregions. However, in this analysis, Bangkok and its five vicinity provinces are separated from NESDB's original classification and used to form another subregion (called the Bangkok Metropolitan Region: BMR). This is because this group of provinces is the largest industrial agglomeration area in the country and is different from other groups of provinces. Therefore, in total we have 19 subregions (see Appendix 5.1). For sectoral scope, I use three levels of industrial classification (i.e. 2-digit, 3-digit, and 4-digit industries) as industrial units to measure localization and urbanization economies. Hence, for subscripts j and r in $lnLE_{jr}$ and $lnUE_r$, j has three units and r has two units of measurement. When we intersect three industrial units with two regional units, we get six entities in which manufacturing establishments are embedded: 2-digit provincial industry, 2-digit subregional industry, 3-digit provincial industry, 3-digit subregional industry, 4-digit provincial industry, and 4-digit subregional industry (Figure 5.1). When the effects of localization and urbanization economies are measured, they are measured at all of these six entities.

[84] According to NESDB, the grouping of provinces is not done primarily for administrative reasons but for regional economic development. In a nutshell, this is based on the ideas that provinces with similar economic characteristics should have similar development strategies; resources necessary for economic development should be shared among those provinces; and development agencies in those provinces should be coordinated. This is one of the area-based or cluster-based development strategies recently endorsed by NESDB.

Figure 5.1: Regional and industrial units used for constructing $lnLE_{jr}$ and $lnUE_r$

		Industrial unit		
		2-digit	**3-digit**	**4-digit**
Regional unit	**Province**	2-digit provincial industry	3-digit provincial industry	4-digit provincial industry
	Subregion	2-digit subregional industry	3-digit subregional industry	4-digit subregional industry

Source: Author

At each spatial and sectoral entity, we have localization and urbanization variables defined as follows:

(1) $lnLE_{jr}\_1$ = localization economies measured at 2-digit and provincial levels;

(2) $lnUE_{r}\_1$ = urbanization economies measured 2-digit and provincial levels;

(3) $lnLE_{jr}\_2$ = localization economies measured at 3-digit and provincial levels;

(4) $lnUE_{r}\_2$ = urbanization economies measured at 3-digit and provincial levels;

(5) $lnLE_{jr}\_3$ = localization economies measured at 4-digit and provincial levels;

(6) $lnUE_{r}\_3$ = urbanization economies measured at 4-digit and provincial levels;

(7) $lnLE_{jr}\_4$ = localization economies measured at 2-digit and subregional levels;

(8) $lnUE_{r}\_4$ = urbanization economies measured at 2-digit and subregional levels;

(9) $lnLE_{jr}\_5$ = localization economies measured at 3-digit and subregional levels;

(10) $lnUE_{r}\_5$ = urbanization economies measured at 3-digit and subregional levels;

(11) $lnLE_{jr}\_6$ = localization economies measured at 4-digit and subregional levels;

(12) $lnUE_{r}\_6$ = urbanization economies measured at 4-digit and subregional levels.

c. Localized competition

To measure the degree of localized competition (or competitive market structure of industry j in region r), I use Herfindahl Index (HI) of market share concentration, which is defined as:

$$HI_{jr} \;=\; \sum_{i \in J_r} \left(\frac{S_{ijr}}{S_{jr}}\right)^2$$

where S_{ijr} is the sales of establishment i in industry j and region r; S_{jr} the total sales of all establishments in industry j and region r; and J_r the set of establishments belonging to industry j in region r. HI_{jr} is a summary measure of the market share of each establishment in the regional industry relative to the whole regional industry market. Its value ranges from 0 to 1. $HI_{jr} = 0$ when all establishments in a regional industry have the same market share; $HI_{jr} = 1$ when the whole market share of a regional industry is dominated by only one establishment. Based on Herfindahl Index, the localized competition variable ($COMP_{jr}$) is constructed as follows:

$$COMP_{jr} \;=\; ln\left(\frac{1}{HI_{jr}}\right).$$

The value of $COMP_{jr}$ ranges between zero and infinity. The increase in $COMP_{jr}$ signifies the increase in the degree of localized competition. This variable is measured at regional industry level and its coefficient can be interpreted in terms of elasticity.

d. Establishment-level variables

At the establishment level, I use seven variables. Each one is defined as follows. First, variable lnK_{ijr} is defined as the natural logarithm of the book value of establishment i's fixed assets valued at the beginning of 2006 (in Thai baht). Second, variable lnL_{ijr} is the natural logarithm of the number of fulltime workers (both production and non-production workers) employed by the establishment. Third, variables EXP_{ijr} and IMP_{jr} are constructed as dummy variable taking the value of one if establishment *i* exports its products (or import products from abroad). Otherwise they take the value of zero. Fourth, FDI_{ijr} is a dummy variable for foreign investment share in establishment *i*. This variable takes 1 if establishment *i* has foreign share (no matter how much the share is), and 0 if it has no foreign investment share. Fifth, variable $INDEP_{ijr}$ is a dummy variable for independent establishment coded 1 if an establishment is an independent establishment and 0 if it is a branch or affiliated company. Finally, variable RND_{ijr} is defined as a dummy variable indicating whether or not establishment *i* invests in R&D. It is coded as 1 if the establishment invests in R&D and coded as 0 if it does not.

e. Region and industrial category dummies (IND_j and REG_r)

Region and industrial category are constructed as multiple dummy variables. I construct region dummies for six of Thai regions, taking the Bangkok Metropolitan Region (BMR) as a base variable (BMR = 0). In the same way, I construct dummies for four industrial categories identified in Chapter 3, taking resource-based category as a base variable (resource-based = 0). Note that both REG_r and IND_j are included to capture unobserved sectoral and regional factors which may affect establishments' labor productivity. Their coefficients are not in the interest of this study.

Variables used in the regression analysis and their construction are summarized in Table 5.1.

Table 5.1: Variables used in the regression analysis

Variables	Variable names	Variable construction
1. Dependent variable (lny_{ijr})	Labor productivity	ln(Value added/Number of workers employed)
2. Independent variables		
lnK_{ijr}	Capital	ln(Values of fixed assets)
$ln\ L_{ijr}$	Labor	ln(Number of workers)
$lnLE_{jr}$	Localization economies	ln(Number of establishments in the same industry and same region)
$lnUE_r$	Urbanization economies	$\ln[1/\sum_j \left(\frac{EST_{jr}}{EST_r}\right)^2]$
$COMP_{jr}$	Localized competition	$\ln[1/\sum_{i\in J_r} \left(\frac{S_{ijr}}{S_{jr}}\right)^2]$
EXP_{ijr}	Export	Dummy (1 = export; 0 = not export)
IMP_{ijr}	Import	Dummy (1 = import ; 0 = not import)
FDI_{ijr}	Foreign investment share	Dummy (1 = having foreign investment share; 0 = no foreign investment share)
$INDEP_{ijr}$	Single-plant establishment	Dummy (1 = independent; 0 = otherwise)
RND_{ijr}	Research and Development	Dummy (1 = having laboratory unit; not having laboratory unit)
IND_j	Industrial category	Industrial category dummies (1 for industry *j* and 0 otherwise)
REG_r	Region	Region dummies (1 for region *r* and 0 otherwise)

Source: Author

5.4 Empirical strategy

5.4.1 Methodological issues

In estimating the effects of agglomeration economies on establishment's productivity, researchers often encounter an *endogeneity* problem (Combes et al. 2008a). Econometrically, the problem of endogeneity arises when one (or more) explanatory variable(s) is/are correlated with the error term in the regression model (i.e., ε_{ijr} in equation (7)), causing the Ordinary Least Square (OLS) estimator(s) to be biased (Wooldridge 2006, ch.15). In the empirical research on the relationship between agglomeration economies and productivity, the problem of endogeneity is said to be generated by two factors: unobserved heterogeneity and simultaneity (Combes et al. 2008a; Martin et al. 2008).

a. Unobserved heterogeneity

The problem of unobserved heterogeneity arises when some characteristics of establishment, industry, and location which can be related to the productivity of establishment and to some other explanatory variables are omitted from the model for various reasons such as lack of data and measurement problem. In this case, those unobserved characteristics are put into the error terms ε_{ijr}, causing ε_{ijr} to be correlated with explanatory variables. Consequently, estimating the model using OLS regression can give biased and inconsistent estimators (Wooldridge 2006, Ch.15).

In the context of this study, the unobserved heterogeneity problem can take place at establishment, location, or industry levels. At the establishment level, for example, such variables as entrepreneurial and management skills and labor ability, which are correlated with establishment's productivity, are put into the error terms, as they are not observable or measurable. It is possible to consider those unobserved characteristics as being correlated with industrial clustering variables in our model (LE_{jr} and UE_r). For instance, entrepreneurs, managers, and workers who are embedded in the industrial cluster may be able to learn from their neighbors, which can enhance their ability. In this case, the variables LE_{jr} and UE_r can be potentially correlated with the error term, ε_{ijr}; and consequently, parameters γ and δ can be biased and inconsistent.[85]

Moreover, some location and industry factors such as local climate, transportation infrastructure, natural resources, and industrial (positive and negative) shocks can in many ways affect the value-added of manufacturing establishments. At the same time, a region endowed with well-developed physical and industrial infrastructures (e.g., specialized education institution, and investment promotion schemes) can be attractive for establishments as well. Thus, the correlations between these unobserved locational and industrial characteristics and variables LE_{jr} and UE_r may exist, causing parameters γ and δ to be biased and inconsistent (Combes et al. 2008a; Martin et al. 2008).

b. Simultaneity

In an econometric sense, the problem of simultaneity occurs when one or more of the explanatory variables is/are jointly determined with the dependent variable (Wooldridge 2006, Ch.16). In the case of this study, it can be considered that localization and urbanization economies variables may be jointly determined along with labor productivity. For instance, highly productive establishments may tend to locate in the industrial cluster, and through the learning process in the cluster, establishments may be able to improve their productivity. In this context, the relationship between industrial clustering and establishment's labor

[85] Martin et al. (2008) also notes that if an entrepreneur is less risk-averse than others, he might tend to distort the labor-capital mix in a particular way, have different innovation strategies and also tend to seek more risky but more lucrative markets. As a result, parameters α and β can be biased as well.

productivity is not unidirectional – they reinforce each other.

In the empirical studies about the effects of agglomeration economies on firms' productivity, it is found that the simultaneity problem can occur through many channels. For example, Martin et al. (2008) note that the negative (or positive) shocks in the region or in the industry may cause firms to close (or open) or lay off (or hire) employees which in some way affect both firms' productivity and degree of agglomeration. Also, when productivity is measured in terms of labor wage, the reverse causality between agglomeration and wage is present. According to Combes et al. (2008b), more productive labor tends to be agglomerated in the larger, denser, and more skilled local labor market. Agglomeration of highly productive labor creates inter-regional wage differentials. This finding implies that firms that decide to locate in the industrially agglomerated areas in order to utilize high skilled labor are those that can afford to pay high wages, and tend to be highly productive firms.

5.4.2 Regression method

As OLS estimator may potentially be biased and inconsistent in the presence of endogeneity, in empirical work it is common to address this problem by using the so-called Two-Stage Least Square (2SLS) regression. This involves finding *instrumental variables* that are correlated with the endogenous explanatory variable(s) but not with the residuals (i.e. such variables are said to be exogenous) (Combes et al. 2008a). The first stage is to regress, based on OLS procedure, the suspected endogenous explanatory variable on instrumental variable(s) and all exogenous variables in the model to obtain the expected values. Then, we perform regression analysis with the endogenous explanatory variable replaced by their expected values to obtain the 2SLS estimator. With the best instrumental variable (i.e., variable exhibiting a very strong correlation with endogenous variable and having no correlation with the error term), the 2SLS estimator is proven to be *asymptotically* unbiased and consistent.[86]

The usage of instrumental variables differs among researchers, depending on the data researchers have in hand and on how variables are expected to meet requirements to be good instruments. Yet, a common practice found in many previous studies is to use a time-lagged endogenous variable. Again, there is no exact rule on the length of time an endogenous variable should be lagged. It is more likely to depend on the available data. For example, Combes et al. (2008b) examines the relationship between productivity (in terms of workers' earnings) and employment density. They address the endogeneity problem using employment density with four-decade lagged time. Rice and Venables (2004) estimate the effects of agglomeration (measured by population size) on productivity and earnings in Great Britain's regions during the period 1995-2001. In their study, the number of regional population in 1851 is used as an instrumental variable. Moreover, to instrument the current level of population density in GB's regions, Anastassova (2006) even uses a longer lagged period (i.e., regional population density in 1801) than that is used in Rice and Venables (2004).

The usage of a lagged endogenous variable as an instrumental variable has some advantages. First, it ensures that the reverse causality will no longer be a problem. For example, past agglomeration may affect current levels of productivity, but not *vice versa*. Second, with a long-time lag, we can be sure somehow that correlation between the lagged variable and the error term will not be present (or will not be very strong). For instance, the level of agglomeration 50 years ago should have no correlation (or very weak correlation) with the firm's current unobserved ability. Therefore, in this analysis I decide to instrument industrial cluster variables (LE_{ij} and UE_r) using their lagged values. Specifically, the level of

[86] However, using 2SLS regression also has a price. Due to the fact that 2SLS relies on the estimated values of endogenous variable, it usually generates larger standard errors than does the OLS. Very often, it results in insignificant estimators. For extensive discussions on procedures and properties of 2SLS regression, see Wooldridge (2002, Ch.5) and Wooldridge (2006, Ch.15 and Ch.16).

agglomerations in 2006 will be instrumented by the level of agglomerations in 1996.[87]

It is worth noting that, the 2SLS estimator is less efficient than OLS estimator when the explanatory variables are exogenous. Therefore, it is important to test for the presence of endogeneity before proceeding to using instrumental variables (Wooldridge 2006, Ch.15). In this study, an endogeneity test is conducted based on the Hausman's test procedures as follows (Wooldridge 2002, Ch.5 and Wooldridge 2006, Ch.15):

Step1: The reduced form for each industrial clustering variable (which is suspected to be endogenous) is estimated by regressing each of them on all other variables in the structural model (including instrumental variables), and saving the residuals. Thus, each LE_{jr} and UE_r is regressed on other explanatory variables and their instrumental variables (LE_{jr} and UE_r with ten-year lag), then the residuals obtained from each regression are saved;

Step2: The structural model (Equation 7 above) is estimated with the residuals obtained from step 1 included;

Step3: The *F-test* is conducted for a joint statistical significance of residuals' coefficients.[88] If the *F-statistic* is significant at a conventional 5% level, then the null hypothesis of no endogeneity is rejected. In other words, if the null hypothesis is rejected, LE_{jr} and UE_r variables are very much likely to be endogenous.

The results from this procedure show that, for all pairs of industrial clustering variables, *F-statistics* are significant at the 1% level (Table 5.2). These results, therefore,

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[87] Bivariate correlations between each LE_{jr} or UE_r variable and their ten-year lag range from 0.512 (in case of $LE_{jr}\_4_{2006}$ and $LE_{jr}\_4_{1996}$) to 0.923 (in case of $UE_r\_4_{2006}$ and $UE_r\_4_{1996}$). Thus, ten-year lags can be taken as instrumental variables because their correlations with our cluster variables are not weak at all.

[88] The F-test is conducted as follows: $F = \left(\frac{RSS_r - RSS_u}{RSS_u}\right)\left(\frac{n-k-1}{m}\right)$, where $RSSr$ = the sum of squared residuals from the restricted model and $RSSur$ = the sum of squared residuals from the unrestricted model; n = number of observations; k = number of parameters in the unrestricted model; and m = is the difference in degrees of freedom between the restricted model (df_r) and unrestricted model (df_{ur}) (i.e. $m = df_r - df_{ur}$) (see Wooldridge 2006, Ch.4).

justify the usage of 2SLS regression in this study.

Table 5.2: The results of *Hausman*'s test for the presence of endogeneity

	Endogenous variables	F-Stat.	Sig.
Test 1	$lnLE_{jr}\_1$ and $lnUE_r\_1$	48.75	***
Test 2	$lnLE_{jr}\_2$ and $lnUE_r\_2$	24.63	***
Test 3	$lnLE_{jr}\_3$ and $lnUE_r\_3$	39.54	***
Test 4	$lnLE_{jr}\_4$ and $lnUE_r\_4$	32.15	***
Test 5	$lnLE_{jr}\_5$ and $lnUE_r\_5$	13.61	***
Test 6	$lnLE_{jr}\_6$ and $lnUE_r\_6$	31.28	***

Note: *** denotes 1% significance level.
Source: Author's calculation

5.5 Results

5.5.1 Descriptive statistics and bivariate correlations

Before conducting regression analysis, the data set was explored in order to remove some problematic cases. The cases were removed if they (1) contain a missing value in any variable; (2) are duplicate cases; (3) are cases of establishment with no workers or no value added which make the dependent variable $ln\ y_{ijr}$ mathematically undefined[89]; or (4) contain some suspicious values (e.g. zeros in sales, fixed asset value, or intermediate costs or very extreme values). Based on these criteria, 8,904 cases were removed from the data set; hence, 65,027 cases (88% of population of establishments) remained to be used for regression analysis. Descriptive statistics for key variables used in the regression and their bivariate correlations are given in Table 5.3 and 5.4, respectively.

[89] Note that lny_{ijr} is defined as *ln(value add/workers)*. This variable is mathematically undefined if number of worker (or value added) is zero.

Table 5.3: Descriptive statistics for key variables used in regression analysis

	Minimum	Maximum	Mean	Std. Deviation
lny_{ijr}	0.23	23.45	10.99	3.42
lnK_{ijr}	6.21	23.61	13.93	2.49
lnL_{ijr}	0.00	9.17	2.02	1.78
$lnLE_{jr}\_1$	0.69	7.37	4.90	1.17
$lnUE_{r}\_1$	1.21	2.56	2.06	0.30
$lnLE_{jr}\_2$	0.69	7.37	4.24	1.22
$lnUE_{r}\_2$	2.01	3.20	2.71	0.23
$lnLE_{jr}\_3$	0.00	7.37	3.65	1.32
$lnUE_{r}\_3$	2.14	3.75	3.18	0.32
$lnLE_{jr}\_4$	0.69	8.00	6.19	1.14
$lnUE_{r}\_4$	1.51	2.58	2.14	0.32
$lnLE_{jr}\_5$	0.69	7.71	5.49	1.20
$lnUE_{r}\_5$	2.42	3.13	2.82	0.23
$lnLE_{jr}\_6$	0.00	7.63	4.83	1.34
$lnUE_{r}\_6$	2.66	3.76	3.33	0.28
$COMP_{jr}$	0.00	3.94	2.01	0.90
EXP_{ijr}	0.00	1.00	0.08	0.28
IMP_{ijr}	0.00	1.00	0.09	0.29
FDI_{ijr}	0.00	1.00	0.04	0.19
$INDEP_{ijr}$	0.00	1.00	0.93	0.25
RND_{ijr}	0.00	1.00	0.03	0.17
# Obs.	65,027			

Source: Author's calculation

As can be seen from Table 5.4, each independent variable, in general, exhibits a highly significant correlation with a dependent variable (i.e., all pairs of bivariate correlation are significant at 1% level). Some variables have bivariate correlation signs which run against expectations. For example, variables EXP_{ijr}, IMP_{ijr}, and FDI_{ijr} have negative correlations with dependent variable. However, this can be changed when we run multiple regression which takes all variables' effects into account simultaneously. It can also be noted from Table 5.4 that correlations between each pair of independent variables are not extremely high, except the correlations among industrial clustering variables. Nevertheless, as all industrial clustering variables will not be put together in the same model specification, their high correlation should not cause a serious multicollinearity problem.

Table 5.4: Correlation matrix of variables used in the regression analysis

	lny_{ijr}	lnK_{ijr}	lnL_{ijr}	$lnLE_{jr}$_1	$lnUE_{r}$_1	$lnLE_{jr}$_2	$lnUE_{r}$_2	$lnLE_{jr}$_3	$lnUE_{r}$_3	$lnLE_{jr}$_4	$lnUE_{r}$_4
lny_{ijr}	1										
lnK_{ijr}	.649[a]	1									
lnL_{ijr}	-.602[a]	-.089[a]	1								
$lnLE_{jr}$_1	-.012[a]	.094[a]	.214[a]	1							
$lnUE_{r}$_1	-.339[a]	-.119[a]	.457[a]	.380[a]	1						
$lnLE_{jr}$_2	-.135[a]	-.004	.232[a]	.854[a]	.384[a]	1					
$lnUE_{r}$_2	-.211[a]	-.074[a]	.294[a]	.112[a]	.798[a]	.097[a]	1				
$lnLE_{jr}$_3	-.167[a]	-.042[a]	.225[a]	.706[a]	.336[a]	.839[a]	.059[a]	1			
$lnUE_{r}$_3	-.099[a]	-.036[a]	.149[a]	-.090[a]	.479[a]	-.112[a]	.824[a]	-.156[a]	1		
$lnLE_{jr}$_4	.017[a]	.110[a]	.189[a]	.872[a]	.359[a]	.715[a]	.154[a]	.574[a]	-.061[a]	1	
$lnUE_{r}$_4	-.347[a]	-.117[a]	.476[a]	.418[a]	.907[a]	.421[a]	.635[a]	.374[a]	.338[a]	.449[a]	1
$lnLE_{jr}$_5	-.109[a]	.007	.202[a]	.749[a]	.364[a]	.870[a]	.135[a]	.715[a]	-.085[a]	.846[a]	.448[a]
$lnUE_{r}$_5	-.292[a]	-.099[a]	.406[a]	.316[a]	.841[a]	.311[a]	.731[a]	.267[a]	.508[a]	.344[a]	.918[a]
$lnLE_{jr}$_6	-.145[a]	-.034[a]	.196[a]	.607[a]	.321[a]	.720[a]	.097[a]	.883[a]	-.130[a]	.679[a]	.394[a]
$lnUE_{r}$_6	-.168[a]	-.059[a]	.243[a]	.089[a]	.576[a]	.079[a]	.634[a]	.037[a]	.688[a]	.063[a]	.611[a]
$COMP_{jr}$	.104[a]	.156[a]	.117[a]	.593[a]	.207[a]	.470[a]	.051[a]	.377[a]	-.092[a]	.515[a]	.216[a]
EXP_{ijr}	-.294[a]	-.053[a]	.480[a]	.057[a]	.258[a]	.054[a]	.214[a]	.040[a]	.158[a]	.017[a]	.239[a]
IMP_{ijr}	-.300[a]	-.077[a]	.449[a]	.051[a]	.298[a]	.042[a]	.239[a]	.024[a]	.164[a]	.016[a]	.286[a]
FDI_{ijr}	-.219[a]	-.071[a]	.311[a]	-.009[b]	.208[a]	-.009[b]	.201[a]	-.010[b]	.158[a]	-.040[a]	.172[a]
$INDEP_{ijr}$	.223[a]	.037[a]	-.372[a]	-.027[a]	-.172[a]	-.020[a]	-.145[a]	.004	-.119[a]	-.019[a]	-.168[a]
RND_{ijr}	.208[a]	.250[a]	-.021[a]	.032[a]	-.028[a]	-0.002	-.017[a]	-.015[a]	-.008[b]	.034[a]	-.026[a]
# Obs.	65,027										

Cont.

	$lnLE_{jr}\_4$	$lnUE_{r}\_4$	$lnLE_{jr}\_5$	$lnLE_{jr}\_5$	$lnLE_{jr}\_6$	$lnUE_{r}\_6$	$COMP_{jr}$	EXP_{ijr}	IMP_{ijr}	FDI_{ijr}	$INDEP_{ijr}$	RND_{ijr}
$lnLE_{jr}\_4$	1											
$lnUE_{r}\_4$	.449[a]	1										
$lnLE_{jr}\_5$	.846 [a]	.448 [a]	1									
$lnUE_{r}\_5$	.344 [a]	.918 [a]	.334 [a]	1								
$lnLE_{jr}\_6$	.679 [a]	.394 [a]	.813 [a]	.282 [a]	1							
$lnUE_{r}\_6$	.063 [a]	.611 [a]	.052 [a]	.814 [a]	.007	1						
$COMP_{jr}$	.515 [a]	.216 [a]	.397 [a]	.162 [a]	.315 [a]	.020 [a]	1					
EXP_{ijr}	.017 [a]	.239 [a]	.012 [a]	.238 [a]	.003	.202 [a]	.039 [a]	1				
IMP_{ijr}	.016 [a]	.286 [a]	.005	.276 [a]	-.009[b]	.217 [a]	.030 [a]	.561 [a]	1			
FDI_{ijr}	-.040 [a]	.172 [a]	-.042 [a]	.174 [a]	-.036 [a]	.153 [a]	0.00	.411 [a]	.401 [a]	1		
$INDEP_{ijr}$	-.019 [a]	-.168 [a]	-.011 [a]	-.164 [a]	.014 [a]	-.140 [a]	-.018 [a]	-.308 [a]	-.265 [a]	-.160 [a]	1	
RND_{ijr}	.034 [a]	-.026 [a]	0.00	-.022 [a]	-.013 [a]	-.012 [a]	.050 [a]	-.015 [a]	-.016 [a]	-.017 [a]	.007	1
# Obs.	65,027											

Note: [a] and [b] denote a statistical significance at 1% and 5% (2-tailed), respectively.
Source: Author's calculation

5.5.2 Regression results

The results of 2SLS regression are reported in Table 5.5. As mentioned before, I measure the effects of localization and urbanization economies at six entities (see Figure 5.1). Thus, six panels in Table 5.5 report the results of 2SLS regression with respect to each spatial and sectoral entity in which localization and urbanization economies are measured.[90] In each panel, four model specifications (denoted by (1), (2), (3), and (4)) are reported: the first specification excludes both regional and industry dummies; the second specification includes only region dummies; the third specification includes only industry dummies; and the last specification includes both region and industry dummies. The inclusion and exclusion of region and industry dummies are denoted by "Yes" and "No", respectively.

The first point to note concerns the global fit of the models. As can be seen, our model specifications explain the variations of dependent variable quite well: the values of R^2 for all of our model specifications range between 0.720 and 0.745.[91] In every panel, the changes in R^2 exhibit the same pattern: the inclusion of region dummies improves the overall model fit in a smaller magnitude to that of the inclusion of industrial category dummies, as shown by the differences in R^2 when only region or industry dummies are included and when neither of

[90] Each panel in Table 5.5 reports the results as follows: (1) Panel a reports the results for model specifications in which localization and urbanization economies are measured at 2-digit provincial industry; (2) Panel b reports the results for model specifications in which localization and urbanization economies are measured at 3-digit provincial industry; (3) Panel c reports the results for model specifications in which localization and urbanization economies are measured at 4-digit provincial industry; (4) Panel d reports the results for model specifications in which localization and urbanization economies are measured at 2-digit subregional industry; (5) Panel e reports the results for model specifications in which localization and urbanization economies are measured at 3-digit subregional industry; and (6) Panel f reports the results for model specifications in which localization and urbanization economies are measured at 4-digit subregional industry.

[91] I report R^2 instead of *Adjusted*-R^2 because *Stata* software used for running the models does not provide *Adjusted*-R^2 value in case of regression with Heteroskedasticity-robust standard errors. However, when I ran separate regression models without Heteroskedasticity-robust standard errors and compared the values of R^2 and *Adjusted*-R^2, I found that the differences between the two were just trivial (i.e. the differences existed at the third or fourth decimal place). This is probably because the sample of establishments that I used, after the cleaning process, accounts for as much as 88% of population of establishments.

them are included. For example, in Panel a, R^2 increases from 0.720 to 0.729 when only region dummies are included (specification 2), while it increases from 0.720 to 0.740 when only industry dummies are included (specification 3). This indicates that industry dummies exert more influence on our model specifications than region dummies do. In every model specification, the values of *F-statistic* are large and highly significant at 1% level, indicating that the joint effects of independent variables are not negligible.

Variables that capture localization economies (LE_{jr}) exhibit interesting patterns. Localization economies tend to have positive effects on establishments' labor productivity at a broader range of industrial aggregation, and negative effects at a narrower range of aggregations. For instance, in Panel a, where localization economies are measured at provincial and 2-digit industrial levels, variable $lnLE_{jr}\_1$ is positive and significant (although the inclusion of industry dummies somehow changes its level of significance). However, once we move to more disaggregate levels of industry (i.e. to 3- and 4-digit levels in Panel b and Panel c, respectively), the effects of $lnLE_{jr}\_2$ and $lnLE_{jr}\_3$ become negative. Similarly, localization economies measured at the subregional level is also positive only for 2-digit industrial clustering while being negative for 3- and 4-digit clustering, as evident in the positive coefficients of $lnLE_{jr}\_4$ in Panel d, and negative coefficients of $lnLE_{jr}\_5$ and *lnLEjr_5* in Panel e, and Panel f, respectively. These results show that spatial clustering of manufacturing establishments in the same 2-digit industry would result in an increase in establishments' labor productivity, whereas spatial clustering of establishments in the same 3- or 4-digit industry is likely to reduce productivity.[92] In particular, the clustering of a broader-

[92] If the television industry is taken as an example, these results state that labor productivity tends to increase when manufacturers of electronic valves, tubes and other electronic equipments are co-located (in the same province or in neighboring provinces) with manufacturers of transmitters, line telephony, line telegraphy, and television receivers, whereas the clustering of electronic equipments manufacturers alone tends to decrease their labor productivity.

range industry is more helpful in improving labor productivity of manufacturing establishments than the clustering of a narrow-range industry. Thus, sectoral scope of industrial clustering matters for production efficiency.

Although we find some evidence to support Marshall-typed industrial clustering here, it can be argued that own-industry clustering does not hold in all cases. As shown, clustering has a positive effect on labor productivity only when it is measured at a 2-digit industrial level, and has negative effects when it is measured at 3- and 4-digit levels. Thus, it is possible that when sectorally related establishments are clustered, this increases the degree of competition for inputs (as they rely on similar inputs) or competition in their final product markets (as they produce similar products) (Lall et al. 2004). This is likely to be the case for the clustering of narrow-range production activities (i.e., 3-digit or 4-digit industries) which require more specific inputs and compete in a specific line of products. Note that negative as well as positive effects of localization economies are as we have expected.

The effects of urbanization economies are, in general, negative and significant, which indicate that diversified industrial structure is not good for productivity improvement in any level of spatial agglomeration (i.e. province or subregion). In other words, the increase in the industrial diversity of the province (or subregion) decreases the labor productivity of manufacturing establishments located in that province (or subregion). As evidenced in every model specification, the effects of $lnUE_r$ variables are negative and highly significant.[93]

Negative effects of urbanization can be expected if an increased agglomeration results in higher congestion costs that outweigh agglomeration benefits (Carlino 1979; Lall et al. 2004; Baldwin et al.2008). However, a problem arises in that this study's measure of

[93] An exception is in model 3 of Panel e. which $lnUE_{r}\_5$ is positive. However, as the level of statistical significance is very weak (*p-value* ≈ 0.095, which exceeds conventional level of 0.05), we can take this as an insignificant case.

urbanization economies only captures regional industrial diversity, without directly capturing industrial density or congestion.[94] To determine whether negative effects of industrial diversity take place because of over-agglomeration or high-congestion costs, I divided the sample into four groups based on provincial industry density (i.e. highest-density, high-density, low-density, and lowest-density subsamples), [95] and then ran 2SLS regressions for each group to see how $lnUE_r$ variables behave. The results are shown in Appendix 5.2.

It is evident from Appendix 5.2 that negative effects of industrial diversity are predominant in the highest-density subsample.[96] The coefficients of $lnUE_r$ variables are negative in every model and statistically significant in five of six models. However, when other subsamples are examined, the results differ. In the high-density subsample, the coefficients of $lnUE_r$ are all positive and significant in five of six model specifications. In two other subsamples, the picture is less clear: coefficients of $lnUE_r$ are negative, positive or statistically insignificant at different levels of spatial and sectoral aggregations. Based on these results, therefore, it can be argued that negative effects of urbanization economies are partially explained by increased agglomeration costs.[97]

[94] In fact, most of empirical studies that test Jacobs's ideas of urbanization economies rarely make a clear distinction between these two phenomena, implicitly assuming that diversity and density are two parallel phenomena of urbanization (Fu and Hong 2010). Thus, although congestion costs associated with increased density can be considered as a negative side of urbanization, the impacts of diversity is still unclear.

[95] Provincial industry density is defined as the number of provincial manufacturing establishments divided by provincial area size. Each subsample consists of 19 provinces.

[96] The highest-density subsample mainly consists of manufacturing establishments in BMR area.

[97] The results of this study are similar to those of Fu and Hong (2010) which find that negative effects of industrial diversity on firms' productivity exist only in cities with a population size of larger than 500 thousand.

Table 5.5: 2SLS regression results

	Panel a.				Panel b.			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept	2.47(0.09) [a]	1.73(0.13) [a]	2.82(0.09) [a]	2.57(0.13) [a]	2.88(0.13) [a]	2.75(0.18) [a]	2.94(0.13) [a]	3.77(0.18) [a]
lnK_{ijr}	0.78(0.00) [a]	0.78(0.00) [a]	0.76(0.00) [a]	0.76(0.00) [a]	0.78(0.00) [a]	0.78(0.00) [a]	0.75(0.00) [a]	0.75(0.00) [a]
$ln\ L_{ijr}$	-1.05(0.01) [a]	-1.04(0.01) [a]	-1.05(0.01) [a]	-1.04(0.01) [a]	-1.04(0.01) [a]	-1.03(0.01) [a]	-1.04(0.01) [a]	-1.03(0.01) [a]
$lnLE_{jr}\_1$	0.09(0.01) [a]	0.13(0.01) [a]	0.02(0.02)	0.01(0.02)				
$lnUE_{r}\_1$	-0.55(0.04) [a]	-0.38(0.05) [a]	-0.23(0.04) [a]	-0.22(0.05) [a]				
$lnLE_{jr}\_2$					-0.15(0.01) [a]	-0.14(0.01) [a]	-0.18(0.01) [a]	-0.21(0.01) [a]
$lnUE_{r}\_2$					-0.30(0.04) [a]	-0.31(0.05) [a]	-0.02(0.04)	-0.25(0.05) [a]
$COMP_{jr}$	0.26(0.01) [a]	0.26(0.01) [a]	0.29(0.01) [a]	0.29(0.01) [a]	0.39(0.01) [a]	0.40(0.01) [a]	0.37(0.01) [a]	0.39(0.01) [a]
EXP_{ijr}	0.10(0.03) [a]	0.05(0.03)	0.07(0.03) [b]	0.04(0.03)	0.09(0.03) [a]	0.05(0.03)	0.06(0.03) [c]	0.04(0.03)
IMP_{ijr}	-0.07(0.03) [a]	-0.07(0.03) [b]	-0.05(0.03)	-0.05(0.03) [c]	-0.14(0.03) [a]	-0.14(0.03) [a]	-0.08(0.03) [a]	-0.10(0.03) [a]
FDI_{ijr}	0.02(0.04)	-0.02(0.04)	-0.02(0.04)	-0.04(0.04)	-0.07(0.04)	-0.09(0.04) [b]	-0.08(0.04) [b]	-0.07(0.04) [c]
$INDEP_{ijr}$	-0.10(0.03) [a]	-0.08(0.03) [a]	-0.04(0.03)	-0.03(0.03)	-0.05(0.03) [c]	-0.03(0.03)	0.01(0.03)	0.02(0.03)
RND_{ijr}	0.99(0.03) [a]	0.98(0.03) [a]	0.98(0.03) [a]	0.97(0.03) [a]	0.98(0.03) [a]	0.98(0.03) [a]	0.97(0.03) [a]	0.96(0.03) [a]
REG_r	No	Yes	No	Yes	No	Yes	No	Yes
IND_j	No	No	Yes	Yes	No	No	Yes	Yes
R^2	0.720	0.729	0.740	0.740	0.724	0.730	0.735	0.745
F-Stat.	16579	11946	13138	10105	16755	12031	13291	10201
Obs.(No.)	65,027	65,027	65,027	65,027	65,027	65,027	65,027	65,027

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

Cont.

	Panel c.				Panel d.			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept	2.54(0.13) [a]	2.42(0.18) [a]	2.75(0.13) [a]	3.30(0.18) [a]	2.24(0.08) [a]	0.58(0.16) [a]	2.67(0.08) [a]	1.78(0.17) [a]
lnK_{ijr}	0.78(0.00) [a]	0.78(0.00) [a]	0.75(0.00) [a]	0.75(0.00) [a]	0.78(0.00) [a]	0.77(0.00) [a]	0.76(0.00) [a]	0.76(0.00) [a]
$ln\ L_{ijr}$	-1.04(0.01) [a]	-1.03(0.01) [a]	-1.04(0.01) [a]	-1.03(0.01) [a]	-1.05(0.01) [a]	-1.03(0.01) [a]	-1.05(0.01) [a]	-1.04(0.01) [a]
$lnLE_{jr}\_3$	-0.16(0.01) [a]	-0.14(0.01) [a]	-0.15(0.01) [a]	-0.17(0.01) [a]				
$lnUE_{r}\_3$	-0.15(0.03) [a]	-0.17(0.04) [a]	-0.01(0.03)	-0.16(0.04) [a]				
$lnLE_{jr}\_4$					0.20(0.01) [a]	0.26(0.01) [a]	0.08(0.01) [a]	0.14(0.01) [a]
$lnUE_{r}\_4$					-0.73(0.03) [a]	-0.28(0.05) [a]	-0.38(0.03) [a]	-0.22(0.05) [a]
$COMP_{jr}$	0.37(0.01) [a]	0.38(0.01) [a]	0.34(0.01) [a]	0.35(0.01) [a]	0.22(0.01) [a]	0.21(0.01) [a]	0.24(0.01) [a]	0.24(0.01) [a]
EXP_{ijr}	0.09(0.03) [a]	0.05(0.03)	0.05(0.03)	0.04(0.03)	0.11(0.03) [a]	0.07(0.03) [b]	0.08(0.03) [b]	0.05(0.03)
IMP_{ijr}	-0.17(0.03) [a]	-0.16(0.03) [a]	-0.10(0.03) [a]	-0.11(0.03) [a]	-0.03(0.03)	-0.03(0.03)	-0.03(0.03)	-0.03(0.03)
FDI_{ijr}	-0.08(0.04) [c]	-0.10(0.04) [b]	-0.07(0.04) [c]	-0.07(0.04) [c]	0.04(0.04)	0.00(0.04)	0.00(0.04)	-0.03(0.04)
$INDEP_{ijr}$	-0.03(0.03)	-0.02(0.03)	0.02(0.03)	0.03(0.03)	-0.10(0.03)	-0.09(0.03) [a]	-0.05(0.03) [c]	-0.05(0.03)
RND_{ijr}	0.98(0.04) [a]	0.97(0.03) [a]	0.97(0.03) [a]	0.96(0.03) [a]	0.99(0.03) [a]	0.98(0.03) [a]	0.98(0.03) [a]	0.97(0.03) [a]
REG_{r}	No	Yes	No	Yes	No	Yes	No	Yes
IND_{j}	No	No	Yes	Yes	No	No	Yes	Yes
R^2	0.725	0.730	0.735	0.735	0.720	0.731	0.734	0.735
F-Stat.	16797	12051	13275	10185	16668	12042	13171	10154
Obs.(No.)	65,027	65,027	65,027	65,027	65,027	65,027	65,027	65,027

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

Cont.

	Panel e.				Panel f.			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Intercept	2.93(0.13) [a]	2.76(0.22) [a]	2.88(0.12) [a]	4.32(0.22) [a]	2.72(0.14) [a]	2.88(0.22) [a]	2.88(0.13) [a]	3.80(0.22) [a]
lnK_{ijr}	0.78(0.00) [a]	0.78(0.00) [a]	0.76(0.00) [a]	0.75(0.00) [a]	0.78(0.00) [a]	0.78(0.00) [a]	0.76(0.00) [a]	0.76(0.00) [a]
$ln\ L_{ijr}$	-1.05(0.01) [a]	-1.03(0.01) [a]	-1.04(0.01) [a]	-1.04(0.01) [a]	-1.05(0.01) [a]	-1.03(0.01) [a]	-1.05(0.01) [a]	-1.04(0.01) [a]
$lnLE_{jr}\_5$	-0.08(0.01) [a]	-0.06(0.01) [a]	-0.16(0.01) [a]	-0.20(0.01) [a]				
$lnUE_{r}\_5$	-0.34(0.04) [a]	-0.36(0.06) [a]	0.08(0.05) [c]	-0.32(0.06) [a]				
$lnLE_{jr}\_6$					-0.11(0.01) [a]	-0.07(0.01) [a]	-0.11(0.01) [a]	-0.12(0.01) [a]
$lnUE_{r}\_6$					-0.20(0.04) [a]	-0.34(0.05) [a]	-0.03(0.04)	-0.29(0.05) [a]
$COMP_{jr}$	0.35(0.01) [a]	0.35(0.01) [a]	0.34(0.01) [a]	0.35(0.01) [a]	0.34(0.01) [a]	0.35(0.01) [a]	0.31(0.01) [a]	0.31(0.01) [a]
EXP_{ijr}	0.08(0.03) [b]	0.05(0.03) [a]	0.04(0.03)	0.03(0.03)	0.08(0.03) [b]	0.06(0.03) [c]	0.05(0.03)	0.04(0.03)
IMP_{ijr}	-0.13(0.03) [a]	-0.12(0.03) [a]	-0.10(0.03) [a]	-0.11(0.03) [a]	-0.15(0.03) [a]	-0.13(0.03) [a]	-0.09(0.03) [a]	-0.10(0.03) [a]
FDI_{ijr}	-0.08(0.04) [b]	-0.09(0.04) [b]	-0.09(0.04) [b]	-0.08(0.04) [b]	-0.08(0.04) [c]	-0.09(0.04) [b]	-0.07(0.04)	-0.06(0.04)
$INDEP_{ijr}$	-0.07(0.03) [b]	-0.05(0.03) [c]	0.00(0.03)	0.02(0.03)	-0.05(0.03) [c]	-0.05(0.03)	0.00(0.03)	0.00(0.03)
RND_{ijr}	0.98(0.03) [a]	0.98(0.03) [a]	0.97(0.03) [a]	0.96(0.03) [a]	0.98(0.03) [a]	0.98(0.03) [a]	0.97(0.03) [a]	0.97(0.03) [a]
REG_r	No	Yes	No	Yes	No	Yes	No	Yes
IND_j	No	No	Yes	Yes	No	No	Yes	Yes
R^2	0.724	0.729	0.735	0.735	0.724	0.729	0.734	0.735
F-Stat.	16698	11981	13247	10164	16700	11985	13202	10135
Obs.(No.)	65,027	65,027	65,027	65,027	65,027	65,027	65,027	65,027

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

Most control variables behave as expected. EXP_{ijr} are positive in every model specification, despite some variation in its statistical significance levels. Thus, manufacturing establishments that export their products are more likely to have higher labor productivity than those that do not.

Compared to branches or affiliated companies, independent establishments tend to be less productive, as evident in the negative coefficients of the $INDEP_{ijr}$ variable in every model specification where it is statistically significant. This evidence supports the notion that establishments embedded in multi-plant firm structure tend to benefit from technological spillovers within the intra-firm network (Henderson 2003).

RND_{ijr} is the most consistent and most robust variable in this analysis. Its coefficients vary between 0.96 and 0.99 in our model specifications and are highly significant at a 1% level in every model. This confirms the importance of firms' R&D investment in generating and enhancing technological capability (Cohen and Levinthal 1989).

$COMP_{jr}$ is another consistent and robust variable in this analysis. Its coefficients are always positive and vary between 0.21 and 0.40 in the model specifications. It is also statistically significant at a 1% level in every model. The positive coefficient of $COMP_{jr}$ can be interpreted that the more market share is equally distributed among establishments (i.e., no single establishment dominates the market), the higher the establishment's labor productivity will be. These results support Porter's (1990, 1998) argument that localized competition, rather than monopolistic local industrial structure, is a key factor to increasing growth and competitiveness of local industry.

Two variables –FDI_{ijr} and IMP_{ijr} – have coefficients that run counter to expectations. The coefficients of the FDI_{ijr} variable are significantly negative (or positive with no statistical significance) which indicate that labor productivity of manufacturing establishments having foreign investment is lower (or not necessarily higher) than that of Thai-owned establishments. Though this result is not consistent with general expectations, it is not unfathomable in the case of Thailand. Previous studies (e.g., Ramstetter 1994, 2001) that compare the labor productivity of foreign-owned and Thai-owned plants find little evidence to suggest that the former has higher labor productivity. The comparative analysis of labor productivity between foreign and Thai plants by Ramstetter (2001) using NSO's industrial census 1996 and industrial survey 1998 find that productivity differentials are not observed as expected. Moreover, the econometric analysis in his study finds no evidence to suggest that foreign ownership will result in higher productivity. The variations in labor productivity differentials are more dependent on other factors such as industrial characteristics and scale economies. For investigation, I divided the sample of manufacturing establishments into four groups based on industrial categories identified in Chapter 3 and re-estimated Model 7 to see the effects of FDI_{ijr} on establishments' labor productivity with respect to each industrial category. The results are given in Appendix 5.3. Positive coefficients are observed in labor-intensive and machinery subsamples but without statistical significance. In resource-based and metal & chemical subsamples, the coefficients are negative and statistically significant. These results are generally similar to those observed by Ramstetter (2001).[98] One possible interpretation is that Thai-owned establishments (i.e., establishments with no foreign investment share) have been able to improve their production efficiency to the same level as (or higher level than) establishments which have foreign investment share. Of course, more investigation is needed to elaborate on this issue.

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[98] I note the differences in model specifications between my analysis and Ramstetter (2001)'s. In his analysis, type of labor (production and non-production), plant ages, scale operation, and industries are controlled for. Despite such differences, the results are generally similar. For example, in Ramstetter (2001), significantly negative coefficients are found in metal and chemical industries; and in many of labor-intensive industries, positive coefficients are not significant.

The coefficients of IMP_{ijr} are negative in every model specification; and despite some variation in its statistical significance levels across the specifications, most of them are significant at the conventional 5% level or less. This indicates that importers of foreign intermediate inputs or products tend to be less productive than non-importers. According to one recent study (Augier et al. 2009), it is argued that the most efficient learning of new technologies embodied in imported products takes place when the importers have sufficient absorptive capabilities, which require a significant investment in human capital. However, the investigation on this issue is beyond the scope of this analysis.

Before closing this chapter, the effects of localization and urbanization economies taking place at different spatial and sectoral settings are summarized based on the results in Table 5.5 (see Figure 5.2). At the provincial level, the agglomeration of sectorally related establishments from 2-digit industry yields a positive effect on manufacturing establishments' labor productivity. However, as we move to agglomerations at 3- and 4-digit levels, the effects become negative. This pattern is also exhibited when the subregion is used as a spatial unit of industrial clustering. For urbanization economies, it is found that their effects, measured in terms of agglomeration of establishments from various industries, are negative in any setting. Thus, depending on sectoral scope of agglomeration, regional industrial specialization, rather than regional industrial diversity, matters for establishments' productivity improvement.

Figure 5.2: Summary of localization and urbanization effects

Regional unit	Industrial unit: 2-digit	Industrial unit: 3-digit	Industrial unit: 4-digit
Province	$lnLE_{jr}\_1$: positive $lnUE_{r}\_1$: negative	$lnLE_{jr}\_2$: negative $lnUE_{r}\_2$: negative	$lnLE_{jr}\_3$: negative $lnUE_{r}\_3$: negative
Subregion	$lnLE_{jr}\_4$: positive $lnUE_{r}\_4$: negative	$lnLE_{jr}\_5$: negative $lnUE_{r}\_5$: negative	$lnLE_{jr}\_6$: negative $lnUE_{r}\_6$: negative

Note: Using information from Table 5.4 (panel a. to panel f.): (1) positive = coefficient(s) is/are positive and statistically significant at 5% level or smaller; and (2) negative = coefficient(s) is/are negative and statistically significant at 5% level or smaller.
Source: Author

5.6 Conclusion

This chapter examined whether industrial clustering helps manufacturing establishments improve their labor productivity. To answer this question, I specified a production function which assumes that labor productivity is influenced by both establishment-specific as well as structural factors. To measure the productivity effects of industrial clustering, the effects of clustering that arise from localization economies (i.e. *spatial agglomeration of establishments operating in the same sector*) were separated from those generated by urbanization economies (i.e. *spatial agglomeration of establishments from different sectors*). It was also assumed that the effects of industrial clustering could vary with spatial and sectoral scopes of agglomeration. For empirical investigation, I applied a cross-section regression analysis using establishment-level data from the Thai manufacturing industrial census 2007. I used the 2SLS regression instead of the OLS regression in order to address the problem of endogeneity in localization and urbanization variables.

The results from 2SLS regression analysis revealed that localization economies do help improve establishments' labor productivity. However, it is found that positive effects of localization take place only for a spatial agglomeration of sectorally related establishments at the 2-digit industrial level. For spatial agglomeration at 3-digit and 4-digit levels, localization effects are negative. These results indicate that industrial clustering of manufacturing establishments operating in a broader range of production activities helps increase productivity. On the other hand, the clustering of establishments operating in a narrow range of activities tends to decrease productivity. As for the effects of urbanization economies, these are found to be negative in any spatial and sectoral settings. As I defined urbanization economies in terms of regional industrial diversity, negative coefficients of urbanization variables indicate that diversified industrial structure is not good for establishments' labor productivity. Further investigation on urbanization economies has revealed that negative effects of industrial diversity are more likely to be attributed to the congestion costs arisen when agglomeration expands further.

As the operational definition of industrial clusters used in this study is based on the concept of localization economies, I conclude that industrial cluster does help improve labor productivity; but its positive effects only take place in a broader range of clustering. The question as to why this is the case is impossible to answer by a quantitative analysis based on manufacturing census data. However, it can be answered by the means of in-depth qualitative analysis based on a case study. The following chapter explores this issue.

Chapter 6

A Case Study of Silk-weaving Industry in Pak Thong Chai District

6.1 Introduction

In chapter 5, I have shown by the means of regression analysis that positive effects of industrial clustering (in terms of same-sector agglomeration) on manufacturing establishments' labor productivity do exist, but only at 2-digit industrial level. On the other hand, same-sector agglomerations at 3-digit and 4-digit industrial levels are negative for labor productivity. Additionally, spatial agglomeration of manufacturing establishments from different sectors harms labor productivity. In this chapter, I address the questions why, how, and under what conditions industrial clustering helps improve labor productivity and the performance of manufacturing establishments. Specifically, the aim of this chapter is to examine the mechanisms through which industrial clustering may help manufacturing establishments improve their economic performance.

This chapter relies on a case study analysis which is based on two rounds of fieldwork conducted during the period August-September 2007 and August-September 2008 at Pak Thong Chai (PTC) district of Nakhon Ratchasima (NR) province. In Thailand, PTC has been well-known for its silk-weaving industry agglomeration. What is interesting about PTC silk-weaving industry is that it has developed from rural cottage industry in which rural households took silk-weaving as an off-farm activity for domestic consumption or exchange in limited local markets to modern industry with more advanced production methods and aims for larger markets – both domestic and export. Thus, it is relevant to examine how such development is possible; and this is the focus of discussions in this chapter.

This chapter is structured as follows. Section 6.2 discusses how data were collected and analyzed. Sections 6.3 and 6.4 provide an overview of PTC district and the history of silk-weaving industry in this district, respectively. In section 6.5, I discuss how vertical linkages between buyer and subcontractors are significant for the development of the latter. Section 6.6 discusses the current situation in which PTC silk-weaving establishments are trapped in a relationship of furious competition and rivalry. It shows what has happened after the buyer has withdrawn from the long-term buyer-subcontractor linkages. Finally, Section 6.7 concludes the chapter and draws some lessons learned from the case study.

6.2 Data and analytical methods

The data used for the analysis in this chapter came mainly from my in-depth interviews with the managers/owners of silk-weaving establishments and the home-based weavers. Such interviews took place during the two rounds of my fieldwork in PTC district. During the first fieldwork (August-September 2007), in-depth interviews were conducted with 40 managers/owners of silk-weaving establishments. During the second fieldwork (August-September 2008) follow-up interviews were conducted with 53 managers/owners of silk-weaving establishments, including 40 managers/owners who were interviewed during the first-round fieldwork. To obtain more comprehensive data, I also interviewed other key informants from the Thai Silk Association (TSA), the PTC Silk Association (PTC-SA), PTC Office of Community Development (PTC-OCD), the NR Office of Industrial Promotion (NR-OIP), and the Thailand Textile Institute (THTI).

The data can be further divided into two types: first, genealogical and historical data showing the establishment's development since it was set up; second, data on current characteristics and performance of sample establishments. The first type of data is descriptive and qualitative, while the second type of data is quantitative and can be used for statistical analysis.

The data are analyzed in two ways. First, I examine the historical evolution of each establishment to see how their performance has changed over time. Specifically, I divide the historical development of PTC silk-weaving industry into two periods: one is the period between 1967 and 1997 in which a group of silk establishments had established a long-term business relationship with a large buyer called *Jim Thompson* (or *The Thai Silk Co. Ltd*.), another more recent one between 1997 and 2008, which is a period where the business relationship with that buyer was ended and establishments had been struggling to survive furious competition and economic recession. A comparison of business performance between these two periods leads us to an understanding of the importance of vertical inter-firm linkages and long-term buyer-subcontractor relationship. Second, I compare the characteristics and performance between establishments that used to establish business relationships with the buyer and those that did not. This is to see whether learning taken place under the buyer-subcontractor relationship helps establishments survive and grow, as compared to those establishments that did not participate in such a relationship.

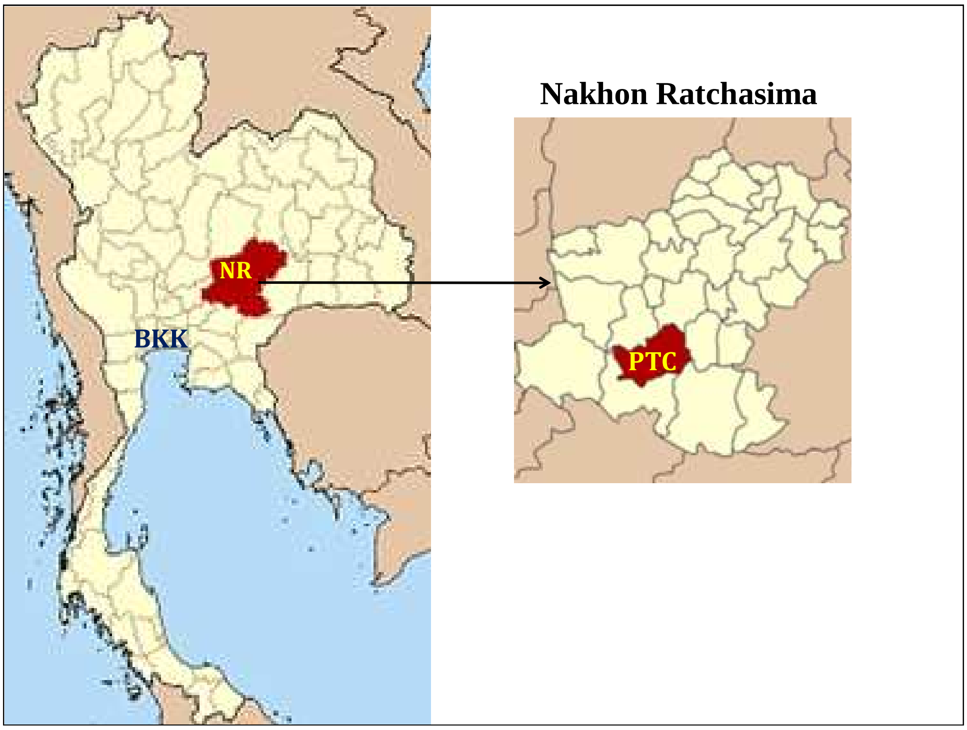
Throughout this chapter, I use the code SE-1, SE-2, ..., SE-53 to denote each of 53 silk-weaving establishments, as it is a simple way of making references.

6.3 Overview of PTC district and its silk-weaving industry

6.3.1 PTC district

PTC is a rural district situated in the southern part of NR province, a province in the Northeastern region which is about 256 Kilometers far from Bangkok (Figure 6.1). PTC district occupies the area of 1,372 km^2 or about 6.7 percent of the area of NR province (20,494 km^2). The district is composed of 16 sub-districts.

Figure 6.1: Location of Pak Thong Chai (PTC) District



Map Source: http://en.wikipedia.org/wiki/Pak_Thong_Chai_District

The population of PTC (115,666 persons) is about 4.5% of NR's (2,555,587 persons). In general, PTC can be considered as rural district as its average population density is very low, just 84 persons per km^2. The most densely populated area is Mueang Pak sub-district – a small town and center of PTC district. The population size of this sub-district was 14,322 persons in 2006, accounting for about 12.4% of PTC population. Since it is a small sub-district (i.e. the area of Mueang Pak sub-district is only 17.9 km^2 or 1.3% of PTC district), population density of Mueang Pak is as high as 1,154.1 persons per km^2.

The average monthly per capita income of PTC is just 4,232 Baht, lower than that of

NR (4,591 Baht), and also much lower than the national average of 6,217 Baht per month. However, the proportion of the poor population in PTC district is only 6.8%, smaller than the NR average (7.6%) and national average (9.6%).

There were 363 manufacturing establishments in PTC (about 22.6% of total manufacturing establishments in NR) in 2006. Agricultural land holders account for only 6.4% and 6.1% for PTC and NR, respectively. This may imply that the importance of agricultural sector is minimal. However, this data may underestimate the importance of the agricultural sector for NR's economy, because agricultural output still accounts for 17.9% of the gross provincial output (GPP) of NR (Table 6.1).

Table 6.1: Overview of PTC district and NR province

	NR	**PTC**
Size (km^2)	20,494	1,374
Population (person)	2,555,587	115,666
Population density (persons in km^2)	125	84
Per capita Income (Baht)	4,591	4,232
Poor population (%)	7.6	6.8
Manufacturing establishments (establishment)	1,065	363
Agricultural land holders (% in total population)	6.1	6.4

Note: All figure presented in the table are the data for the year 2006, except the figure on agricultural land holders which is the 2003 data.
Source: NSO

6.3.2 PTC's silk-weaving industrial clustering and specialization

PTC District is well known for its specialization in silk-woven fabrics production. In 2006, the National Economic and Social Development Board (NESDB) realized the significance of PTC's silk-weaving industry and regarded PTC as one of the top 20 potential industrial clusters in Thailand (KISIA 2006).

According to a survey conducted in 2007 by the PTC District Office of Community Development (PTC-OCD), there were 147 silk-weaving establishments in PTC.[99] However, based on the factory data provided by the Department of Industrial Work (DIW),[100] only 47 out of 147 are registered enterprises. In other words, most of the silk-weaving establishments in this district have operated informally.[101]

Out of 16 sub-districts (SD) in PTC, silk-weaving establishments were only found in seven SDs (see Table 6.2 and Figure 6.2).[102] Mueang Pak SD exhibits a highest concentration in silk-weaving establishments. With the area of only 17.9 km^2, Mueang Pak SD contains as many as 82 establishments, resulting in density of 4.6 establishments per km^2. Contiguous areas to Mueang Pak (such as Takhu SD, Nok Ok SD, and Ngio SD) are also well-known for silk-fabric production.

Most PTC entrepreneurs take a parallel system of silk fabric production: some activities (e.g., yarn-dyeing and some parts of weaving) are operated at the factory site, while some others (e.g., yarn spinning and reeling, and weaving) are contracted out to home-based workers in the villages.

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[99] The survey was conducted as part of the well-known One Tambon One Product (OTOP) project. The PTC-OCD is responsible for identifying local silk-weaving enterprises to take part in the project and coordinating the networks silk-fabrics producers in the district (Interview with PTC-OCD official, August 15, 2007).

[100] Factory data are available at http://www.diw.go.th/diw/data1search.asp (access: March 21, 2011).

[101] Silk-weaving establishments operating in the informal sector are not always small. In fact, during my fieldwork, I found some informal establishments employing more than 100 weavers. However, these establishments only kept 10-15 weavers in-house and contracted out the rest of weaving jobs to a number of home-based weavers.

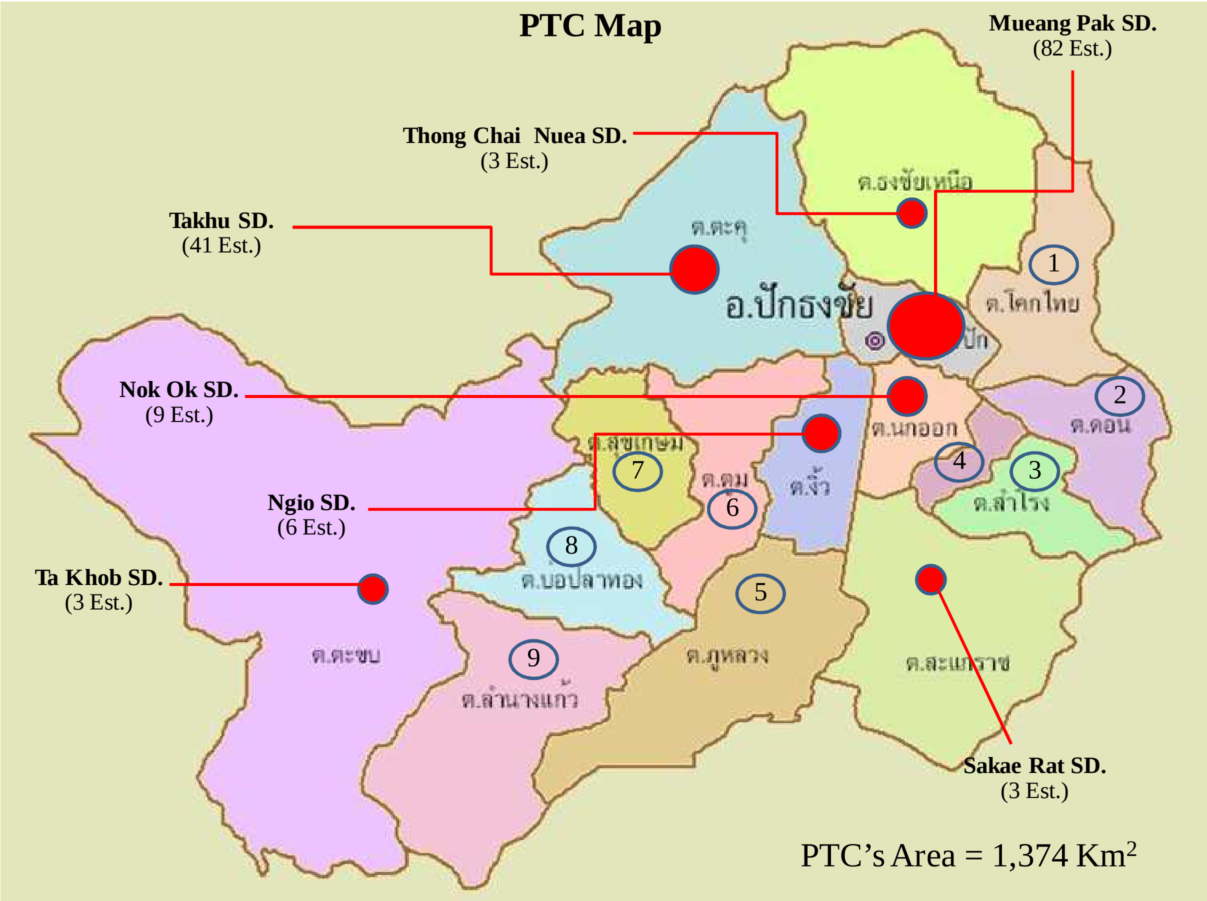
[102] Most parts of southern and western sub-districts are covered by mountains and rivers. These areas have a good irrigation system. Agricultural production (especially, year-round rice production, cassava, corn and sugar cane) is the only economic activity taken by population in these areas. Silk-weaving activity is thus very limited and hardly found in the southern and western sub-districts (Interview with PTC-OCD official, August 15, 2007).

Table 6.2: Sub-district distribution of silk-weaving establishments in PTC district

Sub-District (SD)	**Area**[a] (km^2)	**# Est.**	**Density** (Est./km^2)
1. Mueang Pak	17.9	82	4.56[b]
2. Takhu	108	41	0.38[b]
3. Nok Ok	60	9	0.15[b]
4. Ngio	27	6	0.22[b]
5. Sakae Rat	67	3	0.04[b]
6. Thong Chai Nuea	94	3	0.03[b]
7. Takhop	203	3	0.01[b]
Others (9 SDs)[d]	864	-	-
PTC Total	1,374	147	10.9[c]

Notes: [(a)] = Data on area size in www.thaitambon.com are given in *Rai* and are transformed to area in square kilometer (km^2) by author based on the measure "625 *Rai* = 1 km^2"; [(b)] = Density in establishment per 1 km^2; [(c)] = Density in establishments per 100 Km^2; and [(d)] nine other sub-districts = Khok Thai SD, Samrong SD, Don SD, Tum SD, Lam Nam Kaeo SD, Phu Luang SD, Suk Kasem SD, Kasem Sap SD, and Bo Pla Thong SD.
Source: Author's compilation from www.thaitambon.com

Figure 6.2: Sub-district distribution of silk-weaving establishments in PTC district



Note: Sub-districts with no silk-weaving establishments are (numbered as in the figure): (1) Khok Thai SD; (2) Don SD; (3) Samrong SD; (4) Kasem Sap SD; (5) Phu Luang SD; (6) Tum SD; (7) Suk Kasem SD; (8) Bo Pla Thong SD; and (9) Lam Nam Kaeo SD
Source: Author, based on PTC-OCD's survey data

To see how much PTC district is specialized in silk-weaving industry, I calculate its location quotient (LQ) as follows (see definition of LQ in footnote 1 in Chapter 4): [103]

$$LQ = \left(\frac{PTC\ silk\ weaving\ establishments}{PTC\ manufacturing\ establishments}\right) / \left(\frac{Thailand\ weaving\ establishments}{Thailand\ manufacturing\ establishments}\right)$$

$$= \left(\frac{147}{363}\right) / \left(\frac{4{,}225}{73{,}931}\right)$$

$$= 7.1$$

The LQ formula takes two ratios into account. The first ratio represents the share of number of PTC silk-weaving establishments in the total number of PTC manufacturing establishments. This ratio denotes the extent to which PTC is relatively specialized in silk-weaving activity as compared to its total manufacturing activity. The second ratio represents the share of weaving establishments in total manufacturing establishments in Thailand. This ratio signifies the degree that Thailand is specialized in weaving activities. By comparing these ratios based on the above formula, we can see how much PTC is relatively specialized in silk-weaving activity as compared to the national specialization in weaving activity. The interpretation is straightforward: if LQ is greater than 1, then PTC is more specialized in silk-weaving activity than the national level. Therefore, as LQ for PTC's silk-weaving industry is 7.1, we can say that PTC is about seven times more specialized in silk-weaving activity than the national level.[104]

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[103] Data for PTC's silk-weaving establishments is derived from PTC-OCD' s survey; data for PTC's manufacturing establishments, Thailand's weaving establishments, and Thailand's manufacturing establishments are from industrial census 2007, respectively.

[104] Note that the result of LQ here may overestimate the presence of silk-weaving industry in PTC. This is because in the first ratio the denominator (i.e. 363) is the number of registered establishments, while the numerator (i.e. 147) includes both registered and unregistered (informal) establishments. If we take only registered establishments into account, the ratio will be 47/363 and the resulting LQ will be 2.27 (note that only 47 of 147 silk-weaving establishments are formally registered). Although LQ becomes smaller, it can still show that PTC is at least two times more specialized in silk-weaving industry than the national level.

Aside from specialization, PTC is also the location of a large silk firm called *The Thai Silk Co. Ltd.* (known as *Jim Thompson*). This silk firm employed about 2,000 workers (most of them are PTC residents). Its location in PTC has some significant contribution for the development of silk-weaving industry in this district. This issue is discussed in the following sections.

6.4 A brief history of silk-weaving industry in PTC

It can be said that PTC's specialization in silk-weaving activity nowadays is related to the history of silk industry development in NR province. The origin of silk industry development in NR province dates back to the 1900s (Kasikosol 1998). During the period 1901-1912, King Chulalongkorn (Rama V) made an effort to upgrade the rural silk industry by hiring a team of Japanese experts to supervise a range of silk production activities, from mulberry growing, silkworm rearing, yarn reeling, to silk weaving. The aim was to transfer Japanese silk production technologies to Thai officials and farmers.[105] Between 1901 and 1907, there were 18 Japanese silk experts who severed as supervisors for technology transfer. And in order to facilitate such technology transfer, the government established supporting institutions such as the Department of Silk Technology and the Silk Technical School in Bangkok.

The government selected NR province as a center for disseminating new technologies to other areas in the Northeast region. In 1904, it established the Division of Silk Technology (DST) in NR. The government also imported yarn reeling and weaving machines

[105] The main reason for importing Japanese silk production technologies was that Japan was the world leader in silk industry in that time. Since 1868, silk yarn and other silk-related products accounted for about 46% of Japan's export. Moreover, between 1906 and 1910, Japan had become the top silk exporting country, overtaking China which had been the top exporter for a long time (Yonio and Toshiharu, 1987 cited in Kasikosol 1998, p. 16).

and related equipment from Japan and installed them in the DST. During the period 1904-1912, the DST provided several training courses related to sericulture, yarn reeling, and weaving to rural people who wanted to learn new technologies. By 1909, there were 1,258 people attending such training courses. These people were expected to spread new technologies throughout NR province (Kasikosol 1998, p. 64).

However, after having implemented the rural silk development project for 12 years, the government came to think that the project was not as successful as had been expected. The cost of running the project exceeded revenue for every year between 1901 and 1912. By 1912, the government had spent a total of 1,235,169 baht but received only 74,672 baht from selling silk yarn, fabrics, and cloths (Kasikosol 1998, p. 85). More importantly, rural residents were not enthusiastic about learning new methods. The number of people who attended the training courses was much fewer than that was expected by the government. Therefore, in 1912, the government decided to abandon the whole project (Kasikosol 1998, p. 86).

There is no report to examine to what extent the twelve-year project helped upgrade the rural silk industry. But according to some studies (DAE 1965; Samuthakub 1994; Kasikosol 1998), after 1912, rural silk industry in NR (as in everywhere else) was not more than a cottage industry in which rural households took silk production seasonally as off-farm activity for household consumption or for small trade with their neighbours. The labor force survey of Thai population in 1915 shows that out of 56,517 labor force in NR, there were 29,614 (52.4%) persons engaged in weaving activity (Kasikosol 1998, p. 107). However, the production of silk-woven fabrics and cloths was carried out mainly in the individual households by applying traditional methods inherited from their ancestors (Kasikosol 1998, p. 121). Before the 1960s, the silk-weaving industry in PTC was not different from the whole of NR province (note that PTC is a district in NR Province); that is, silk-weaving activities were carried out by small households as off-farm activities for household consumption or for exchanging in local markets (Samuthakub et al. 1994, pp. 25-26). This indicates that the efforts made by the government failed to transfer Japanese silk technologies to rural areas. The situation did not change until the late 1960s in which the upgrading of product and production processes took place with some PTC silk-weaving establishments. Such upgrading started when a group of PTC silk-weaving establishments had established a subcontracting relationship with a large buyer, i.e., *Jim Thompson* (hereafter, JT). In Section 6.5, I show that vertical inter-firm linkages between JT and PTC silk-weaving establishments under a subcontracting arrangement are relevant for the upgrading and development of the latter.

6.5 Vertical inter-firm linkages and performance of rural silk-weaving establishments

The discussion in this section covers the issues of how JT had established subcontracting relationship with PTC establishments, what elements of upgrading took place after such relationship was established, and whether the economic performance of PTC producers who established subcontracting relationship with JT improved. The main samples to be discussed here are 13 silk-weaving establishments (SE-1 to SE-13 in Appendix 6.1) who in the past had subcontracting relationships with JT. From now on these establishments will be referred to as JT's former subcontractors.[106]

[106] In fact, there were 27 PTC silk-weaving establishments that used to be JT's subcontractors in the period between 1967 and 1997; however, my fieldwork only covered 13 of them.

6.5.1 The establishment of subcontracting relationship between JT and PTC producers

JT was established in 1948.[107] Until 1982, JT did not have its own production site; it only focused on design, quality control, and marketing activities. Between 1948 and 1965, JT purchased all silk fabrics from home-based weavers in a small community in Bangkok called Ban Krua community. But once JT had successfully established itself in the silk textile market, it needed to produce more sophisticated products on a larger scale to respond to increasing market demands. Ban Krua community alone was no longer capable of responding to such needs.[108] JT had to look for more suppliers and it chose PTC producers as new suppliers.

Despite the fact that the PTC's silk weaving industry during the 1960s was less advanced in terms of production technology, JT still believed that PTC had a higher potential than other areas to serve as its silk-fabric supply base. There were three main reasons as to why JT chose PTC.[109] First, in JT's view, there were a sufficiently large number of households in PTC involved in the silk-fabric production so that a large supply could be guaranteed.[110]

Second, although there were a number of individual households involved in silk-fabric production as an off-farm activity in many areas (especially, in the Northeast), JT still

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[107] JT was founded by a former US military officer and businessman named *James Harrison Wilson Thompson* (1906-1967). He came to Thailand during the Second World War and served as a military intelligence officer in Bangkok. After the end of the war, Thompson entered the silk business by establishing the Thai Silk Company Limited in 1948 (www.jimthompson.com).

[108] Interview with JT's personnel manager (September 11, 2007).

[109] In my interview with JT's personnel manager at PTC plant (September 11, 2007), the manager was asked to identify the reasons why JT chose PTC as its supply base.

[110] Interview with JT's personnel manager (September 11, 2007). The reason why a large number of PTC households were involved in silk weaving activities may be related to the PTC's history. During the era of the King Rama I (1736 - 1809), there were a large number of Laotian immigrants who migrated from Vientiane to PTC district as a result of the war between Siam (the old name of Thailand) and Laos in 1778. Those Laotian immigrants brought with them the knowledge and skills in silk-fabric production, which were transferred to their descendents who permanently resided in PTC. Thus, knowledge and skills in silk-fabric production took root in PTC as a result of knowledge transfers from generation to generation (see CAC 1994). It became common for PTC population (especially, women) to carry out silk weaving activities after the farming season (Interview with the president of PTC Silk Association, September 4, 2008).

encountered the main challenges: how to access those individual households?; how to coordinate the production processes carried out by individuals households who lived dispersed in the villages?; and how to guarantee the quantity and quality of silk fabrics produced by those individual households? As JT lacked the information and knowledge on the rural silk-weaving industry, it had to find some local entrepreneurs to help it overcome these challenges. Apparently, in the rural PTC's silk-weaving industry at that time, there existed some local entrepreneurs who coordinated production processes under the putting-out arrangements (see Sub-section 6.5.2). In JT's view, those local trader would have the potential to serve as its subcontractors due to their knowledge of silk-fabric production and their experience in coordinating silk-weaving activities.[111]

Local entrepreneurs lived in the rural town (Mueang Pak Sub-district) and were involved in trading activities. Some entrepreneurs (e.g., the founders of SE-2 and SE-3) ran a small shop selling various household goods, while other entrepreneurs (e.g., the founders of SE-1 and SE-9) collected local products (such as silk fabrics and rice) to sell in Bangkok. These entrepreneurs have three important characteristics to serve as JT's subcontractors. First, they were not involved in agricultural production; therefore, they could concentrate on silk-fabric production and silk-fabric trade on a year-round basis.[112] This is different from the

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[111] In fact, JT did not have many choices in choosing suppliers because the rural silk-weaving industry everywhere in Thailand at that time was underdeveloped and unorganized. Rural people only took silk production seasonally as their off-farm activity. It was thus difficult to expect a year-round supply of products. In JT's view, the silk-weaving industry in PTC seemed to be better organized than in other regions at least because it was to some extent operated on a commercial basis by local silk-weaving entrepreneurs (Interview with JT's personnel manager, September 11, 2007).

[112] According to my interviews with 13 JT's former subcontractors, none of them has ever involved in agricultural production. These entrepreneurs mentioned that they did not have knowledge about agricultural production and did not own farm land. They carried out silk-weaving activities on a year-round basis. For example, the owners of SE-1, SE-6, and SE-9 mentioned that during the off-farm season, they coordinated production activities which they put out to homeworkers who worked on a seasonal basis. But in the farm season, they worked by themselves or hired family workers or a few wage weavers. According to these owners, agricultural seasonality did not seem to be the main problem for operating silk-weaving activities

individual weavers who were agrarians and carried out silk-weaving activities during the non-farm season. Second, the entrepreneurs had financial capital accumulated from their trading activities to invest in silk-weaving activities.[113] Finally, these entrepreneurs had their own networks of homeweavers. Before the arrival of JT in 1967, these entrepreneurs had already invested in silk-fabric production. They invested in inputs necessary for producing silk-fabrics (e.g. silk-yarn, bleaching and dyeing chemicals, handlooms, and hand-spinning tools), distributed these inputs to individual homeworkers who worked for them on a piece-based payment, and then collected silk-fabrics from those homeworkers. Although local entrepreneurs still relied on traditional production technologies, for JT, these entrepreneurs possessed some potential to serve as its subcontractors because: first, these entrepreneurs had financial capital which was necessary if they would have to run a large scale of silk-fabric production; and second, these entrepreneurs had access to individual weavers who were important for the production process.[114]

Finally, in JT's view, PTC was geographically more appropriate than other regions in the Northeast to serve as its silk-fabric supply base. As PTC is not too far from Bangkok, it would be easier for JT to transport the products from PTC to Bangkok and to maintain the contacts between JT's head office (in Bangkok) and its supply base in PTC.[115] The distance between PTC and Bangkok is just about 250 kilometers, less than the distance between Bangkok and other regions in the Northeast where silk-weaving activities were prevalent such

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at that time. This is because seasonal fluctuation in demand for silk fabrics was different from seasonal pattern of agricultural demand for labor: the demand for silk fabrics was high in off-farm season (December-April) and low in farm season (May-November).

[113] Note that in PTC district in the 1950s and 1960s, the own financial capital was very important because there was no official financial services operated in PTC at that time (Interview with the president of PTC Silk Association, September 4, 2008).

[114] Interview with JT's personnel manager (September 11, 2007).

[115] Interview with JT's personnel manager (September 11, 2007).

as Khon Kaen and Chaiyaphum.[116] In fact, Nakhon Ratchasima province, where the PTC district is situated, is considered as the gate way to the Northeast. Geographically, it is closer to Bangkok than any other provinces in the Northeast.

Before subcontracting relations were established, JT sold its business ideas to PTC entrepreneurs. This led to an agreement between JT and PTC entrepreneurs that JT would concentrate on product development and marketing and PTC entrepreneurs must act according to JT's advice and help.[117] At first, there were 10 PTC entrepreneurs that established a subcontracting relationship with JT. The number of subcontractors increased, as JT market had expanded. In 1987, the number of subcontractors was at a peak (27 subcontractors) before it started to decline since then (see Table 6.3).

It should be noted that the nature of subcontract between JT and 13 subcontractors is different from subcontract used widely in modern industrial organizations which rely more on a written contract for legal enforcement. The subcontracting arrangements between JT and 13 subcontractors were not based on official contracts. Rather, it was based on a set of purchasing orders. The conditions (e.g., delivery time and characteristics of fabrics) might vary from order to order, but normally new purchasing order would be continued after a previous order was fulfilled. For example, JT might put an order of 10,000 meters of a particular design to one subcontractor and ask that subcontractor to deliver 2,000 meters every month. After this order was fulfilled, a new order would immediately arrive with new designs and new conditions.[118] This kind of practice lasts long without legal enforcement. The duration that JT promised to buy products varied from 15 years (in the cases of SE-4 and SE-9) to 38 years (in the case of SE-7).

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[116] The distances from Bangkok to Khon Kaen and from Bangkok to Chaiyaphum are 449 and 342 kilometers, respectively.
[117] Interviews with JT's personnel manager and JT's technician (August 23, 2008).
[118] Interview with the owner of SE-7 (September 3, 2007).

Table 6.3: Trend in JT's performance and its relation with PTC subcontractors

	Year											
	1967	**1977**	**1982**	**1986**	**1987**	**1992**	**1997**	**1998**	**2002**	**2004**	**2006**	**2008**[6]
Performance indicators												
1. Sales[1]	<100	n.a.	n.a.	455	n.a.	n.a.	n.a.	1,450	n.a.	2,340	2,604	n.a.
2. Output[2]	n.a.	n.a.	631	n.a.	818	1,549	1,156	n.a.	1,123	n.a.	n.a.	904
3. Number of technicians[3]	n.a.	n.a.	3	n.a.	7	11	17	n.a.	18	n.a.	n.a.	18
4. Labor[4]	n.a.	n.a.	150	n.a.	300	700	1,000	n.a.	1,700	n.a.	n.a.	2,000
Relation with PTC subcontractors												
5. Output from PTC subcontractors[5]	n.a.	n.a.	600	n.a.	720	800	267	n.a.	187	n.a.	n.a.	30
6. Output from PTC subcontractors (%)[6]	100	100	95.1%	n.a.	88%	51.7%	30%	n.a.	20%	n.a.	n.a.	3.3%
7. Number of PTC subcontractors	5	17	17	n.a.	27	17	10	n.a.	2	2	1	1

Notes: (1) annual sales in million baht; (2) total hand-woven silk fabrics in thousand yards per year; (3) the number of technicians at the PTC's silk-fabric production plant; (4) number of persons employed in silk fabric production processes; (5) silk fabrics from subcontractors in thousand yards per year; (6) proportion of hand-woven silk fabrics sourced from subcontractors as percentage of JT's hand-woven silk fabrics; and [6] data at the end of August 2008.
Source: Author's interviews with JT's personnel manager and JT's technician (August 23, 2008), except data on sales which is from Bunditkul (2005)

Although JT has established its own factory in 1982, subcontractors still played an important role as main suppliers of silk-woven fabrics. From Table 6.3 it can be seen that the proportion of hand-woven silk fabrics that JT sourced from subcontractors was 100% before 1982, and still occupied the major part until 1992. This indicates that JT depended on subcontractors for products, while subcontractors depended on JT in terms of marketing, product development, and better production methods.

In terms of performance, JT has enjoyed constant growth since it was established. Sales grew from less than 31.2 million baht in 1967 to 2,604 million baht in 2006 (211.4% annually). The number of persons employed in silk fabric production processes constantly increased from 150 in 1982 to 2,000 in 2008 (47% annually). Output (hand-woven silk fabrics) increased from 631,000 yards in 1982 to 1,123,000 yards in 2002 (3.9% annually). By the end of August 2008, JT already produced 904,000 yards, which accounted for 80.5% of the whole-year output in 2002. In addition, the number of technicians also increased from three in 1982 to 18 in 2008.[119]

Table 6.3 also shows that JT's output sourced from subcontractors have constantly declined in both absolute and relative terms after 1992. Such a decline is explained by to two important reasons. First, the demand for JT's product in both domestic and export markets rapidly dropped during the period 1993-94 because of two events: political riot in Thailand in 1992 and slack demand in foreign markets following the Gulf War in 1991.[120] JT had to stop some production lines and stop purchasing from subcontractors. Some subcontractors had

[119] Note that the number of technicians here refers to the number of technicians at the PTC's silk-fabric production plant only. In fact, JT also has a garment production plant in Bangkok and a yarn-reeling plant in PTC; each plant has its own technicians. In each stage of silk-fabric production (i.e. yarn-dyeing, silk-weaving, and printing) at the PTC plant, there will be at least one technician whose main responsibility is to supervise the production activities (Interviews with JT's personnel manager and JT's technician, August 23, 2008).

[120] Interviews with JT's personnel manager and JT's technician (August 23, 2008).

gone bankrupt. When JT recovered from recession after 1995, many subcontractors already produced for other buyers and, though they received orders from JT again, they learnt not to depend too much on any single buyer. Second, after getting involved in JT's subcontracting arrangement for many years, subcontractors became potential competitors for JT in many product lines. In the period between 1982 and 1992, which is said by all 13 JT's subcontractors to be the booming period for PTC's silk-weaving industry, there were many buyers seeking business relations with them. 13 JT's former subcontractors started to produce for buyers, although all of them claimed that they produce for JT the most. Out of the 13 JT's subcontractors that I interviewed, five started to export through export agents and eight established retail stores in some tourist market places. Consequently, JT stopped outsourcing new and sophisticated product designs and stopped providing further knowledge and technologies to these subcontractors due to the fear of losing its competitiveness. Products that were outsourced were only those outsourced previously. However, even though the long-term subcontracting relations have almost ended in recent years, almost three decades of such relations had brought about upgrading in products and production processes, which are discussed below.

6.5.2 Elements of upgrading

This subsection shows that after the sample 13 establishments started their business with JT, the upgrading took place in terms of (1) acquisition of new machine/tools; (2) change in the organizational form of work; (3) change in product designs and patterns; and (4) improvement in methods related to yarn-dyeing, weaving, and job-checking.

a. Acquisition of new machine/tools

Becoming subcontractors of JT, the 13 sample establishments faced new demands from JT: first, they had to produce a larger volume of fabrics within a specified period; second, they needed to produce a longer piece of fabric with the same characteristics (e.g. same colour, pattern, and texture). It was necessary to replace the traditional handlooms, which were widely used before 1967, by the more superior machines/tools. JT introduced the so-called *flying-shuttle loom* to its subcontractors due to the following advantages of the machine: first, the flying-shuttle loom is smaller than the traditional one, which made it easier for subcontractors to increase the number of looms in a limited space of workshop; second, the flying-shuttle loom has a capacity to weave longer fabrics than the traditional one, which made it easier to control for constant characteristics along a piece of fabrics; and third, the flying-shuttle loom has the capacity to weave faster than the traditional one (approximately three times faster). In fact, the capacity of the flying-shuttle loom to weave silk fabrics is as fast as 100-120 wefts per minute which can weave 2-3 yards of fabrics in one hour, while the traditional loom take about one hour to weave one yard. [121]

Aside from the flying-shuttle loom, JT also introduced spinning machines to its subcontractors. Before 1967, subcontractors used hand-spinning tools to perform this job. But when more purchasing orders from JT came, silk yarns had to be spun into beams more quickly than before. This made hand spinning no longer appropriate. The spinning machine is more advantageous than the hand-spinning tool in that: first, as it is attached with the motor, it can spin much faster than the latter; and second, it can spin silk yarns into several beams at the same time, while the hand-spinning machines can only do it one by one. In fact, the motor-spinning machine can spin as many as 80 beams of silk yarn simultaneously and take

[121] Interview with JT's technician (August 23, 2008).

only one minute to finish the job, while hand-spinning can spin only one beam in one minute. Therefore the new machine is about 80 times faster than the traditional one.[122]

JT's technicians played important roles in transferring the new technologies to subcontractors. First, they brought these machines from Bangkok and demonstrated how to operate them. Second, they helped install these machines in subcontractors' workplaces and trained subcontractors how to operate them.[123] Although JT did not provide credit to buy new machines for these13 subcontractors, all of them similarly said that they were willing to install new machines after they observed that the capacity of the new machines was much higher than the traditional ones. More importantly, because JT guaranteed to buy all outputs, subcontractors found it cost-effective to install new machines. For example, the owner of SE-1 mentioned that around the late 1960s her establishment invested about 100,000 baht to buy new machines, but this investment was covered within one or two years as JT purchased her products.

b. Change in the organization of work

Before entering JT's subcontracting arrangements, 13 JT's former subcontractors relied on the putting-out system. They carried out only bleaching and dyeing activities in their workshops and put out other jobs (e.g. winding of warp-yarn, spinning of weft and warp yarns, pattern wrapping, and weaving) to homeworkers who were paid on a piece-work basis. Under this putting-out arrangement, homeworkers enjoyed flexible working conditions because they worked in their domestic premises and were not forced to finish the job in a limited time and were not directly supervised by the putter-out. But after subcontracting relations with JT were established, those JT's former subcontractors replaced the putting-out

[122] Interview with the manager of SE-5 (September 11, 2007).
[123] Interview with JT's technicians (August 23, 2008).

system with the factory system. This change occurred for several reasons: first, as subcontractors of JT, they needed to produce high-quality fabrics to meet quality standards set by JT otherwise their products would be rejected; second, they had to produce a large volume of fabrics in a limited time and deliver to JT within a specified delivery date. Under the putting-out system, it was difficult for those subcontractors to follow up the production activities. They, therefore, built a factory and concentrated all production activities in-house so that they could easily supervise the whole production processes.[124]

In fact, JT also encouraged its subcontractors to build factories since it was easier for JT' s technicians to supervise production processes in one place than in dispersed home-based workshops. Moreover, JT allocated a purchasing order to each subcontractor by considering their production capacity, based on its observation of how well the production activities were organized.[125] This indirectly forced subcontractors to set up their factories in order to secure purchasing orders from JT. In some cases, JT even provided financial support for entrepreneurs who wanted to expand their businesses or enlarge their factories.[126]

Under the factory system, weavers were closely supervised by their employers, which helped improve productivity because they became more disciplined in their work. JT's former subcontractors claimed that factory workers could produce about 180-200 yards per month on average, while home-based weavers could produce only about 90-120 yards of silk fabrics per month. The lower productivity of the latter is due to their not being supervised by their employers.

One may argue that the factory system may become unnecessary if, under the putting-out system, quality control is effectively introduced. This is not the case for 13 JT's

[124] Interviews with JT's former subcontractors (see Appendix 6.1 for interview dates of SE-1 to SE-13).
[125] Interview with JT's personnel manager (August 23, 2008).
[126] For example, the owner of SE-4 said she received interest-free loan of 30,000 baht from JT to enlarge her factory (Interview with the manager of SE-4, August 25, 2007).

former subcontractors who mentioned some difficulties in introducing effective quality control under the putting-out system. First, lack of sufficient personnel prevented them from following up production processes and ensuring effective quality control. Before becoming JT's subcontractors, there was little follow up of the production process: the subcontractors just acted as a coordinator of production processes and only went to homeworkers' workplace to pass intermediate inputs from one process to another. However, this practice became inefficient once they started to produce for JT. When JT placed a large purchasing order, these subcontractors needed to increase the number of homeworkers and to ensure that homeworkers would take care of production processes more seriously than before. Consequently, they needed to follow up more frequently. But as they lacked sufficient personnel, bringing the production processes into one place was a better option because they could supervise numerous workers thoroughly.

Second, since homeworkers lived dispersedly in the villages far from PTC's center where JT's former subcontractors were located, close supervision of the production processes at homeworkers' premises was difficult. In this situation, the decision making about production methods and supervision of production processes was left to homeworkers because they owned machines/tools and worked at their houses. JT's former subcontractors could only examine the attributes of final products. This practice was no longer efficient under JT's subcontracting arrangements because if there was any defect JT would reject the whole piece of fabric. Thus, close supervision of production processes became necessary and it could be done more easily under the factory system than the putting-out system.

Finally, the introduction of factory system by subcontractors also has something to do with new technologies: flying-shuttle looms and yarn-spinning machines. According to the owner of SE-6, as both types of machines were new and expensive, she was reluctant to leave these machines with homeworkers. It was easier for her to check and control when these machines were concentrated in her factory.[127]

c. Changes in designs and patterns of products

Before entering JT's subcontracting arrangement, JT's former subcontractors that I interviewed mainly produced the old-styled silk fabrics called *Mudmee* (*Ikat*), *Pa Puen* (plain-colour fabric) and *Pa Kaoma* (cross-colour fabric), which could be found anywhere in the Northeast. The number of designs and patterns were quite limited just to meet local demands. For example, the owner of SE-9 has mentioned that her main customers were local people who passed by and those customers usually preferred to buy *Madmee* or *Pa Puen* of two to four yards to make a piece of cloths. But after having subcontracting relation with JT, new patterns and designs were introduced to subcontractors by JT's technicians.

The nature of markets in which JT was embedded is one of the important factors that explain characteristics of its product. As JT mainly targeted high-end domestic (e.g., tourist market) and export markets in which fashion changed quickly and the life-cycle of a particular product was quite short, [128] product designs must be responsive to such highly fluctuating market demands. Accordingly, products that JT brought to subcontractors were very diverse. For example, JT's fabrics were cross diversified according to weight (light,

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[127] As large sunk costs of introducing factory system were totally borne by subcontractors, despite JT's provision of some financial assistance, it is reasonable to think of this as a risky step which might pose a problem on subcontractors: at the beginning of adopting factory system, costs per unit of output tend to be very high, as compared to costs incurred under putting-system. This can be considered as a trade-off of being JT's subcontractors. Even so, factory system was yet adopted by 13 JT's former subcontractors. Why? Based on my interviews, I found that 13 JT`s former subcontractors were inclined toward risk-minimizing behavior. They did not put a large amount of money to invest in building a large factory immediately after they became JT's subcontractors. Rather, they reinvested in expanding their factory (and production scale) only after they accumulated some capital derived from continuously selling to JT.

[128] According to JT's personnel manager, around 30% of sales are from export and 70% are domestic market in which tourist market is the main domestic market of JT (Interview with JT's personnel manager, September 11, 2007).

middle, and heavy),[129] colors, patterns, texture, and purposes (e.g., clothing, decorating, and home textile) which yield countless styles of fabrics.

All JT's former subcontractors were trained by JT's technicians. For example, when JT ordered a fabric of particular design, JT's technicians would demonstrate how to produce it. Later, after continuously learning new patterns and designs, JT's subcontractors were able to diversify their products and markets into others besides JT. For example, the owner of SE-2 claimed that she received knowledge about modern designs from JT by which later enabled her to establish lucrative product lines such as heavy-weight home-textile fabrics used for decoration and furniture in hotels and restaurants.

d. Improvement in yarn-dyeing and weaving methods and job-checking technique

In terms of yarn-dyeing methods, before entering JT's subcontracting arrangements, JT's former subcontractors used a traditional method inherited from their ancestors and were not worried much about the quality of products. Their yarn boilers were small and could boil only about a kilogram of silk yarn at once, sufficient only for weaving three to four yards of fabric. They use colors for dyeing from plants, which had disadvantages of (1) fading easily; (2) taking a long time to dye; and (3) having limited number of color tones. They paid little attention to water quality or temperature for dyeing. For example, almost all 13 sample establishments (except SE-5) mentioned that they mainly used low-quality water from canals for dyeing. After subcontracting arrangement was established, JT persuaded these subcontractors to use the permanent chemical dyes and high-quality colors used in modern textile factories, instead of natural colors. Importantly, it taught these subcontractors about the

[129] According to the owner of SE-1, light-weight fabric refer to a fabric woven by one or two silk thread, middle-weight woven by three to six thread, and heavy weight woven by more than six thread (Interview with the owner of SE-1, August 11, 2007).

advanced color mixture formulas: how to produce a particular color, what colors should be mixed, in what proportion, what chemicals should be used in the process. Aside from that, JT also introduced new type of yarn boiler to these subcontractors, which has a capacity of large scale bleaching and dyeing. New yarn boilers had a capacity to boil at least 10 kilograms of silk yarn, which was higher than the traditional small boilers that could boil on one or two kilograms. New yarn boiler saved time that workers spent on dyeing because it could boil larger amount of yarn at once. For example, the owner of SE-7 claimed that if he used the traditional boiler he might have to boil 10 times to get the same amount, but this could be done in one go using a new boiler. Moreover, large boiler made it easier to assure that a whole piece of long fabric would have consistent color and texture because longer yarns were boiled at once.

In terms of weaving, 13 JT's former subcontractors learned better weaving techniques to produce fabrics of more sophisticated patterns and of higher quality. In order to weave such fabrics, JT gave guidance and set rules for these subcontractors to follow. First, JT required these establishments to use standardized tools such as the two-thousand-teeth reed which produces a more fastened texture. Before becoming JT's subcontractor, 12 of the 13 sample establishments (except SE-5) used the one-thousand-seven-hundred-teeth reed which produced an unfitted texture. Second, in order to weave more sophisticated patterns, JT trained the owners and the weavers of these establishments how to work with the flying-shuttle looms attached with more "healds", an important tool to create the pattern in the texture: the more sophisticated the pattern, the more healds required. Weavers needed to start from weaving with two healds and gradually shifted into weaving with more healds step by step. Moreover, JT's technicians also trained the weavers of 13 sample establishments to "read the pattern". For example, since weavers had to weave based on models given by JT as an example, JT's technicians trained those weavers on how to weave the patterns or how to change and correct the patterns when any defect happened.

Additionally, 13 JT's former subcontractors also learned from JT job-checking method, a kind of quality control (QC). According to 13 JT's former subcontractors, QC activities usually took place in the production processes. The owners of these establishments had to supervise their weavers closely to prevent or limit defects. Before delivering products to JT, the owners of these establishments had to examine carefully again each piece of fabric. As JT also did not want to reject any order it made, it passed all the quality control guidelines to subcontractors in order to minimize defects. There were several guidelines applied to different types of fabric, which the 13 JT's former subcontractors would obtain as check lists for checking their products item by item.[130]

It is important to note here that having been involved in JT's subcontracting arrangements not only brought about improvement in machines/tools, work organization, products, and production methods as examined above. It is also associated with growth in establishment size and output of these 13 former subcontractors.

6.5.3 JT's practices for the upgrading of its subcontractors

To get silk-woven products that meet its requirements, JT had to do something to guarantee that its subcontractors could produce according to the orders they received. From the interviews, I found some practices by JT which had a significant effect on enhancing its subcontractors' production capability including (1) close cooperation between JT's

[130] For example, the owner of SE-2 claimed that very detailed guidelines regarding the weight and texture of fabrics were carefully transferred to her by JT's personnel. JT's personnel regularly demonstrated the ways to examine products based on standard rules of JT. For instance, in one square inch of fabric, how many threads should be woven?; for one yard of the two-thread, three-trade, or six-thread fabrics, how much weights it should take?; in one square yard, how many ragged threads were allowed?, and so on (Interview with the owner of SE-2, August 15, 2007).

technicians and subcontractors in the process of product development; (2) regular visits by JT's technicians to subcontractors' workplaces; and (3) provision of guidelines and feedback by JT personnel.

a. Close cooperation between buyer and subcontractors for product development

Before 1982, JT focused on product development and marketing, leaving production activities to its subcontractors. To ensure that products would meet its standards, JT sent its technicians to stay at PTC district where they could work closely with local subcontractors. As Table 6.3 shows, during the period between 1967 and 1992 in which JT sourced more than 50% of hand-woven fabrics from subcontractors, the number of technicians who worked at subcontractors' site increased from 3 to 7 and to 11 in 1977, 1987, and 1992 respectively.

Business relations between JT and these subcontractors before 1982 took two forms. First, JT gave purchasing orders with specified product characteristics (or sample products) so that its subcontractors could produce to meet the orders that it required. This was done in case of products that subcontractors already obtained knowledge and skills to produce. In this case, JT's technicians just went to the workplace to follow up or give some instructions when problems occurred. Second, JT's technicians worked side by side with its subcontractors to develop products which were new to the latter. In this case, JT invested in raw materials and bore all costs related to product development. The owners of JT's former subcontractors stated that, in the process of product development, JT's technicians stayed at their workplaces for the whole day and everyday to supervise the whole production processes and work together with them until succeeding in product development. This process allowed knowledge transfer from JT's technicians to 13 subcontractors to take place. After subcontractors had obtained knowledge and skills to produce by themselves, JT's technicians would leave the whole production process to the subcontractors, but still followed up regularly.

b. Regular visits

One of the main jobs of JT's technicians who resided in PTC was to visit subcontractors regularly. The main purpose of these visits was to supervise production processes, to share information with subcontractors, and to check or sort out products before sending them to the purchasing station. JT's former subcontractors mentioned that after JT put purchasing orders on them JT's technicians had visited their workplaces to supervise and follow up almost every day.[131] Since JT's technicians resided in PTC, its subcontractors could easily approach them for help with any technical problems.[132] For example, the owners of SE-1 and SE-4 mentioned that when problems occurred, they usually stopped producing and waited until JT's personnel came because if they kept producing or solving problems by themselves, the products would be downgraded, or even rejected by JT.

As JT did not have its own factory before 1982, regular visits to subcontractors by JT's personnel was the best way to internalize production activities as if those activities had taken place in JT's own factories. Regular visits increase face-to-face interactions between JT's personnel and its subcontractors. Consequently, it helps reduce mistakes, defects, as well as subcontractors' opportunistic behavior.[133]

c. Provision of guidelines and feedback

JT's former subcontractors learned about QC from JT in three ways. First, they

[131] Interviews with the owner of SE-5 (August 27, 2007) and JT's technician (August 23, 2008).
[132] Interviews with JT's former subcontractors (see Appendix 6.1 for interview dates of SE-1 to SE-13).
[133] Interviews with JT's personnel manager and JT's technician (August 23, 2008).

learned from guidelines provided by JT. Since JT did not want to reject the products that it outsourced, when it put purchasing orders on subcontractors it also provided detailed guidelines, which normally contained all things-to-do to meet JT's orders. Second, JT also provided guidelines at workplaces of its subcontractors, which occurred when JT's personnel visited subcontractors' workplaces to follow up the production processes. In addition, subcontractors also learned from feedback. Generally, when subcontractors delivered finished products to JT's purchasing station, JT's QC personnel would examine and grade their products, and then return the products to the subcontractors with the explanation of grading evaluation. In this way, JT's former subcontractors learned what mistakes they made and what to improve if they wanted their products to meet JT's standards next time.

These practices are supportive for the upgrading of 13 JT's former subcontractors that I interviewed. Repeated and face-to-face interactions between JT's personnel and subcontractors allowed information sharing and knowledge transfers to happen. These practices continued for almost three decades in PTC. They helped these 13 former subcontractors learn to improve their products and production processes.

6.5.4 Performance of subcontractors under JT's subcontracting arrangement

Table 6.4 shows the trend in size (measured by the number of workers) of 13 JT's former subcontractors throughout the period between the time they were established and 2007. In this table, 12 of 13 JT's former subcontractors started as micro or cottage industries employing less than 10 workers.[134] Most establishments started to grow in the year they became JT's subcontractors or a few years later. For example, SE-1, SE-4, and SE-13 grew out of cottage establishments in the year they became JT's subcontractors. Other

[134] In Thailand, cottage establishment refers to rural establishments employing less than 10 persons and applying traditional production technologies.

establishments (SE-2, SE-3, SE-7, SE-9, SE-10, SE-11, and SE-12) grew soon after they became JT's subcontractors.

Once these 13 establishments started to grow after entering JT's subcontracting arrangements, they grew continuously until they exited the arrangement. In fact, by 1992, 10 out of 13 establishments had increased the number of workers to more than 50; four of them even employed more than 100 workers. Note also that, for 11 out of 13 establishments (except SE-5 and SE-7), the number of workers did not drop from the previous five years during the period these establishments were involved in JT's subcontracting arrangements (the symbol is either ▲ or ▬ in this period).

The main reason why these JT's former subcontractors continued to increase their workers is because the purchasing orders from JT increased continuously since the 1960s. Moreover, by that time hand-made fabrics were still the main products demanded by JT.[135] It was not possible to substitute human weavers with machines in order to produce faster. Thus, to produce a large quantity of hand-made silk fabrics and to deliver them by a specified delivery time, subcontractors had no choice but to enlarge their factory site and employment.

[135] Up until the end of 1990s, JT's majority products were still hand-made silk fabrics, not machine-made fabrics (Interviews with JT's personnel manager and JT's technician, August 23, 2008).

Table 6.4: Trend in employment (number of workers) of JT's former subcontractor

	Year established	**Enter JT's sub.**	**Exit JT's sub.**	**1962**	**1967**	**1972**	**1977**	**1982**	**1987**	**1992**	**1997**	**2002**	**2007**
SE-1	1958	1967	1997	1	2(▲)	2(▬)	2(▬)	4(▲)	4(▬)	4(▬)	4(▬)	3(▼)	2(▼)
SE-2	1977	1980	1997	N.E.	N.E.	N.E.	1	2(▲)	2(▬)	2(▬)	3(▲)	3(▬)	2(▼)
SE-3	1960	1967	1993	1	1(▬)	2(▲)	2(▬)	3(▲)	4(▲)	4(▬)	4(▬)	2(▼)	2(▬)
SE-4	1976	1982	1997	N.E.	N.E.	N.E.	1	2(▲)	2(▬)	3(▲)	4(▲)	4(▬)	2(▼)
SE-5	1985	1985	2005	N.E.	N.E.	N.E.	N.E.	N.E.	2	2(▬)	3(▲)	2(▼)	2(▬)
SE-6	1962	1970	1992	1	1(▬)	1(▬)	2(▲)	3(▲)	4(▲)	4(▬)	4(▬)	2(▼)	1(▼)
SE-7	1967	1970	Not Exit	N.E.	1	2(▲)	3(▲)	3(▬)	3(▬)	3(▬)	2(▼)	2(▬)	2(▬)
SE-8	1965	1975	1993	N.E.	1	1(▬)	1(▬)	2(▲)	2(▬)	3(▲)	3(▬)	2(▼)	2(▬)
SE-9	1960	1977	1992	1	1(▬)	1(▬)	1(▬)	3(▲)	3(▬)	3(▬)	3(▬)	2(▼)	2(▬)
SE-10	1972	1975	1992	N.E.	N.E.	1	2(▬)	4(▲)	4(▬)	3(▼)	2(▼)	2(▬)	2(▬)
SE-11	1965	1967	1993	N.E.	1	2(▲)	2(▬)	3(▲)	4(▲)	4(▬)	4(▬)	3(▼)	2(▼)
SE-12	1974	1982	2000	N.E.	N.E.	N.E.	1	1(▬)	2(▲)	2(▬)	2(▬)	1(▼)	1(▬)
SE-13	1967	1972	1995	N.E.	1	2(▲)	3(▲)	3(▬)	3(▬)	3(▬)	2(▼)	2(▬)	2(▬)

Notes: (1) Number 1 = employ not more than 10 workers; 2 = employ 10-50 workers; 3 = employ 51-100 workers; and 4 = employ more than 100 workers. (2) "N.E." the establishment did not exist in that year. (3) The symbol (▲) = number of workers increased from the previous five years; (▼) = number of workers decreased from the previous five years; and (▬) = number of workers did not change from the previous five years.
Source: Author's interviews

Table 6.5 shows the trend in output (silk-woven fabrics in yard per year) of 13 JT's former subcontractors. It shows that most of these establishments started to increase the level of output after they became JT's subcontractors, following the pattern shown in Table 6.4. Most establishments started to increase the level of output after they became JT's subcontractors and the level of output did not drop from the previous five years during the period that they were involved in JT's subcontracting arrangements (again the symbol is either (▲) or (▬) in this period). By 1992, the year when JT's hand-woven silk fabrics reached the highest level (see Table 6.3), 10 out of 13 subcontractors also reached the level of producing more than 50,000 yard per year.

To see the extent to which JT's demand for products from subcontractors contributes to subcontractors' output growth, I divide JT's output sourced from subcontractors by the number of subcontractors in each subsequent year (see Table 6.3); it results in the average output per subcontractor of 35,294, 26,666, 47,058, and 26,700 yards per year in 1982, 1987, 1992, and 1997, respectively. These numbers imply that 10 out of 12 subcontractors heavily depended on JT for output growth in 1982 in which these 10 subcontractors produced silk fabrics of not more than 50,000 yards per year. In 1987, 6 out of 13 subcontractors whose level of output was not more than 50,000 yards per year still heavily depended on JT. However, after 1987 we cannot estimate the proportion of output that most subcontractors produced for JT because10 out of 13 already produced larger than 50,000 yards per year (no upper bound imposed). However, all 13 former subcontractors that I interviewed claimed that JT was still their largest buyer until they exited JT's subcontracting arrangement.

After 1997, some of JT's former subcontractors experienced some drop in employment and output. The economic crisis in 1997 and later the overall economic recession followed from the 2006 coup d'état are also mentioned by JT's former subcontractors as significant causes of their business recession. Many of them claimed that during economic crisis between 1997 and 2000, all purchasing orders from tourism-related business such as hotels and restaurant were canceled. In 2000, buyers started putting purchasing orders again. Following the coup d'état in 2006, however, purchasing orders reduced sharply, like in the previous economic crisis; and this recession has lasted until recently (2008, by the time of my interviews).[136]

[136] Interviews with JT's former subcontractors (see Appendix 6.1 for interview dates of SE-1 to SE-13).

Table 6.5: Trend in output (silk fabrics in yard per year) of JT's former subcontractor

	Year established	**Enter JT's sub.**	**Exit JT's sub.**	**1962**	**1967**	**1972**	**1977**	**1982**	**1987**	**1992**	**1997**	**2002**	**2007**
SE-1	1958	1967	1997	1	2(▲)	3(▲)	3(▬)	4(▲)	4(▬)	4(▬)	4(▬)	2(▼)	2(▬)
SE-2	1977	1980	1997	N.E.	N.E.	N.E.	1	2(▲)	3(▲)	4(▲)	4(▬)	2(▼)	2(▬)
SE-3	1960	1967	1993	1	1(▬)	2(▲)	3(▲)	3(▲)	4(▲)	4(▬)	3(▼)	2(▼)	2(▬)
SE-4	1976	1982	1997	N.E.	N.E.	N.E.	1	2(▲)	2(▬)	4(▲)	4(▬)	4(▬)	4(▬)
SE-5	1985	1985	2005	N.E.	N.E.	N.E.	N.E.	N.E.	2	4(▲)	3(▼)	2(▼)	3(▲)
SE-6	1962	1970	1992	1	1(▬)	1(▬)	2(▲)	2(▬)	4(▲)	4(▬)	3(▼)	2(▼)	1(▼)
SE-7	1967	1970	Not Exit	N.E.	1	2(▲)	3(▲)	3(▬)	3(▬)	3(▬)	2(▼)	2(▬)	2(▬)
SE-8	1965	1975	1993	N.E.	1	1(▬)	2(▲)	2(▬)	3(▲)	3(▬)	4(▬)	4(▬)	4(▬)
SE-9	1960	1977	1992	1	1(▬)	2(▲)	2(▬)	3(▬)	4(▲)	4(▬)	2(▼)	2(▬)	2(▬)
SE-10	1972	1975	1992	N.E.	N.E.	1	2(▲)	2(▬)	4(▲)	4(▬)	3(▼)	3(▬)	2(▬)
SE-11	1965	1967	1993	N.E.	1	2(▲)	2(▬)	3(▲)	4(▲)	4(▬)	2(▼)	2(▬)	2(▬)
SE-12	1974	1982	2000	N.E.	N.E.	N.E.	1	2(▲)	3(▲)	3(▬)	3(▬)	2(▼)	1(▼)
SE-13	1967	1972	1995	N.E.	1	2(▲)	4(▲)	4(▬)	4(▬)	4(▬)	2(▼)	2(▬)	2(▬)

Notes: (1) Number 1 = not more than 10,000 years per year; 2 = 10,001-25,000 yards per year; 3 = 25,001-50,000 yards per year; and 4 = more than 50,000 yards per year. (2) "N.E." the establishment did not exist in that year. (3) The symbol (▲) = output increased from the previous five years; (▼) = output decreased from the previous five years; and (▬) = output did not change from the previous five years.
Source: Author's interviews

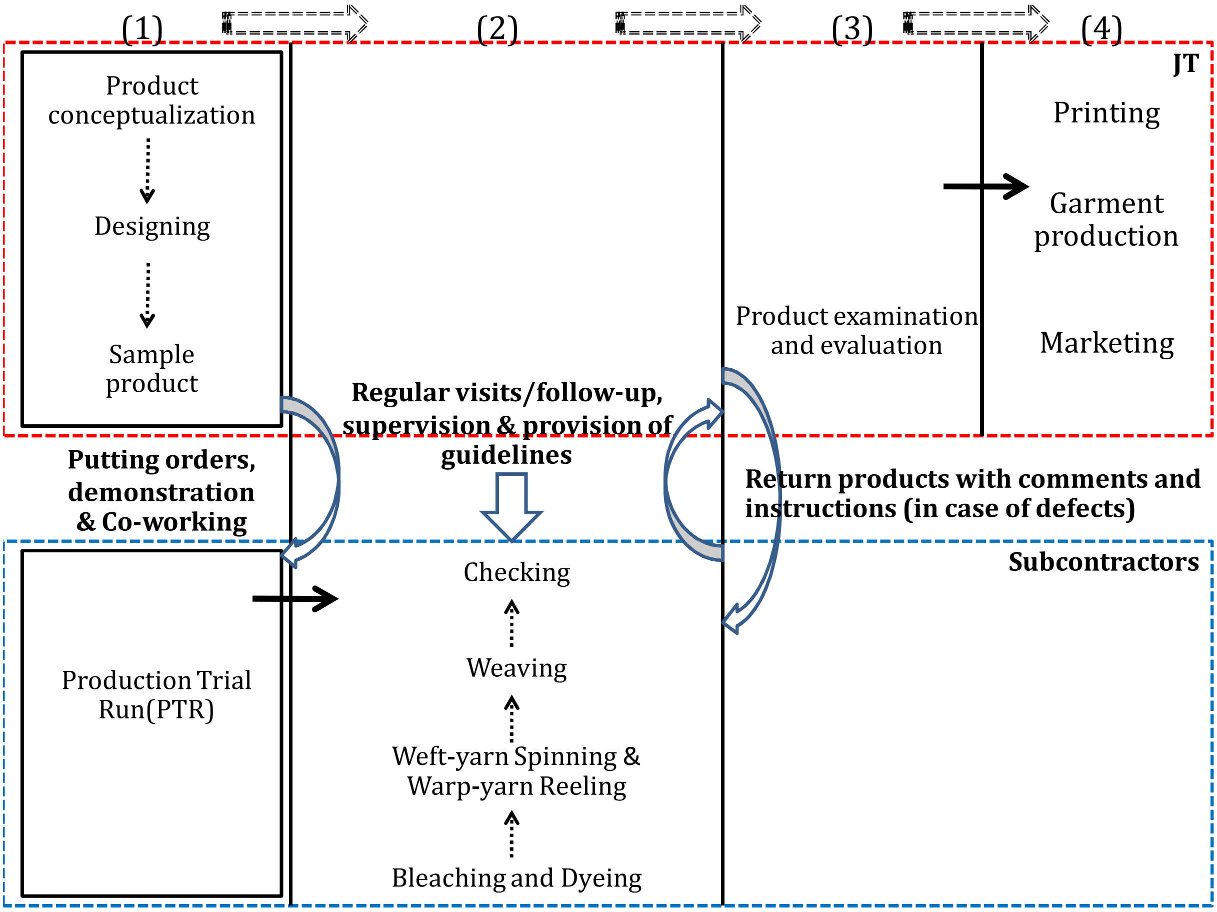
From Tables 6.4 and 6.5, it can be argued that the growth in employment and output of the sample 13 establishments is related to their being JT's subcontractors. Learning under JT's subcontracting arrangement also helped them adjust their operations to new market conditions. Even after JT stopped outsourcing, most establishments did not face a serious drop in employment and output. Most of them could manage to survive and did not return to where they started: cottage industry (except SE-6 and SE-12). In fact, most of 13 JT's formers subcontractors that I interviewed claimed that the continuous reduction in JT's demand did not seriously affect them, thanks to their having less dependence on JT since the late 1980s. Although they still considered JT as a major buyer until they exited their subcontracting arrangements with JT, they already established themselves in new markets other than JT, especially such lucrative markets as high-end domestic and export markets. These former subcontractors maintained that they did not face difficulties in adapting themselves into new market conditions as demand conditions under new buyers were not different from those under JT. Similar to producing for JT, producing for new buyers whose markets were either high-end domestic or export requires special attention to be paid to quality control, punctuality, and patterns/designs specified by buyers. Characteristics of products (i.e., designs and quality) they produced for new buyers were not more sophisticated than those for JT. They did not need to change production methods or techniques from those used before. JT's former subcontractors tended to find production methods/techniques provided by JT standardized ones, which could always be applied to other buyers' demands. In terms of quality control, new buyers were not as strict as JT. All 13 sample establishments claimed that their new buyers only checked final products and never examined production processes at subcontractors' factories.

It is important to note that little evidence was found about alternative sources of the improvement of products and production methods examined above. Training courses and access to experts did not take place until recently. In fact, PTC's silk industry just began to attract attentions from government agencies in the later years when it became widely known to the customers already. PTC's silk industry became a target of government's support after the silk industry was declared as a strategic industry of NR Province in 2001 when attempts to improve production capabilities were made through training courses.[137] However, the real beneficiaries of those training courses seem to be individual homeworkers rather than JT's former subcontractors. This is because JT's former subcontractors rarely attended training courses as they found those courses did not provide them with methods that were better than they had obtained from JT.[138]

I end this section with a summary of vertical inter-firm relationship between JT and its PTC subcontractors taking place under subcontracting arrangement. Figure 6.2 illustrates this relationship. The processes run from product development (1), silk-fabric production (2), product examination and evaluation (3), to upstream production (4). The upper box (red dotted line) represents the processes tanking place in JT, while the lower box (blue dotted line) represents the processes taking place in the workplace of JT's subcontractors.

[137] Interviews with NR-OIP official (August 15, 2007) and PTC-OCD official (August 30, 2007).
[138] Interviews with JT's former subcontractors (see Appendix 6.1 for interview dates of SE-1 to SE-13).

Figure 6.3: Vertical inter-firm relations between JT and its PTC subcontractors (1982-1997)



Notes: 1. Numbers in parentheses denote the processes as follows: (1) = product development process; (2) = silk-fabric production process; (3) = product examination and evaluation process; (4) = downstream production process.
Source: Author's interviews

Product development process can be divided into two sub-processes: one consists of product conceptualization, designing and making of product samples; another one is the product trial run (PTR). The first sub-process took place in JT, because JT wanted to keep information and knowledge on product designs within firm in order to maintain its competitiveness. The second sub-process took place in PTC subcontractors' workplace. For new products and new designs, the trial process is very risky. In this case, JT would bear all costs and take responsibility for all mistakes and defects that occurred. In the process of product development, JT not only gave the purchasing orders but its personnel also demonstrated the production and worked closely with subcontractors at the subcontractors' production site. These practices allowed for information sharing and knowledge transfers. Note that PTR process was done in PTC subcontractors' workplace only until 1982. After JT has established its own factory, this process was gradually concentrated in its factory due to its concern about information leakages and about losing its competitiveness to subcontractors. Thus, by 1977, PTR process was no longer done at subcontractors' site.

The process of silk-fabric production took place in subcontractors' production site. This process consists of four sub-processes: bleaching and dyeing, spinning of weft yarn and reeling of warp yarn, weaving, and product checking. In silk-fabric production process, JT's personnel visited subcontractors' production site regularly to supervise the production, to provide some production guidelines, or to help subcontractors solve production problems. Also, regular face-to-face interactions taking place in this process allow for information exchange and knowledge transfers.

After the products (silk-fabrics) had been delivered to JT, its technicians would examine, evaluate, and grade the products. In the case that the products had too many defects or were distorted from their original design, the products would be rejected and returned to subcontractors with some comments and instructions. If the products were accepted, they would go to JT's upstream production processes such as printing and garment making before selling them in the markets.

It is worth noting that information sharing and knowledge transfer based on face-to-face interactions are possible because buyer and subcontractors are located close to each other. After JT decided to establish subcontracting relations with PTC subcontractors, it recruited technicians and other personnel (e.g. PTC site managers) and sent them to PTC production site. Having located close to its subcontractors, JT could follow up and supervise production processes closely as if the production had taken place in its own factory. For example, when a mistake happened in production process, JT's technicians were able to help subcontractors solve the problem quickly and directly. Therefore, co-location of buyer and subcontractors in the same area is more effective in facilitating face-to-face interactions than if that buyer and subcontractors are located far from each other.

6.6 Characteristics of recent PTC silk-weaving industry: After 1997

Since 1997, long-term business relations between JT and its PTC subcontractors have been no longer significant. JT has become almost fully vertically integrated. Production activities that are currently contracted out account for a very small portion (i.e., only 3.3% of the current output is derived from subcontractors, see Table 6.3). The question is whether there exist new modes of inter-firm linkages – horizontal or vertical – which help improve the performance of PTC silk-weaving industry. This section shows that horizontal cooperation among PTC producers does not exist because they are trapped in a situation of cut-throat competition, while vertical linkages between PTC producers and new buyers are not as effective as linkages with JT. Note that the following discussion is about the whole 53 sample of PTC silk-weaving establishments, not only the 13 former subcontractors of JT.

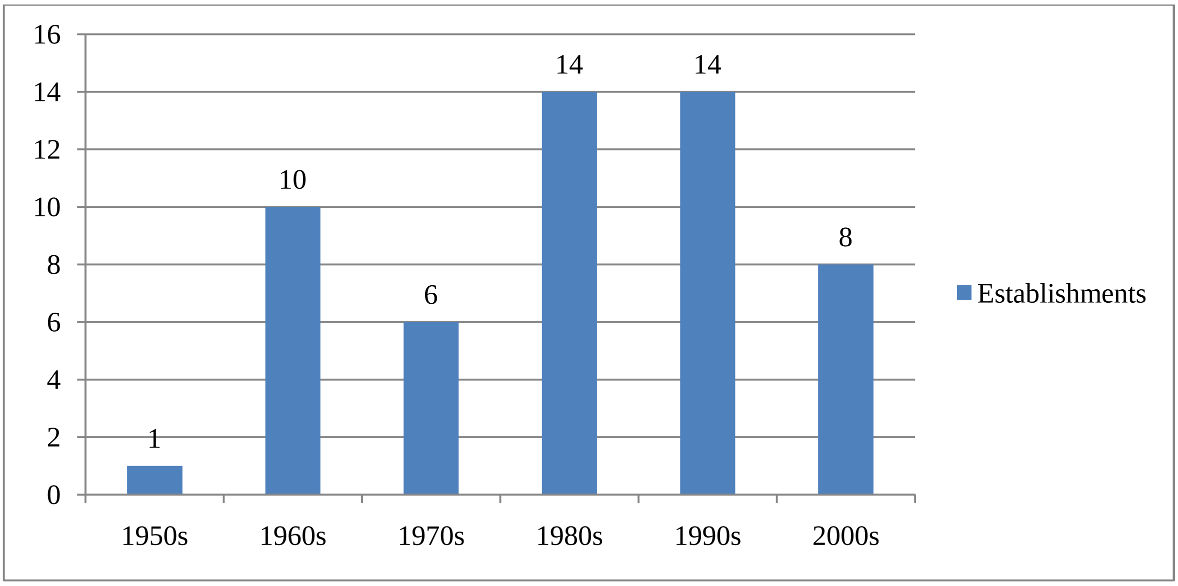
6.6.1 Intense competition, increased silk-yarn prices, and low cooperation

Since the late 1980s onward, competition among PTC silk-weaving establishments has become intense, resulting in low profit margins. At the same time, prices of silk yarns – key raw material – tend to increase over time which intensifies the problem of low profit margins. Despite these problems, cooperation among PTC producers to collectively solve the problems is still very low.

a. Intense competition

Competition among PTC silk-weaving establishments is due to the fact that during the late 1980s to the early 1990s, the number of new establishments increased significantly. As can be seen from Figure 6.4, most of the sample 53 silk-weaving establishments were set up after 1980s onward.[139]

Figure 6.4: The number of PTC's silk-weaving establishments by the years of establishment



Note: These numbers are of the 53 sample establishments.
Source: Author's interviews

An increase in the number of establishments has resulted in increased competition. This is because when new establishments (i.e., those established after 1980) entered the markets, they did not introduce new products, but chose to compete on the existing product

[139] According to some enterprise owners (SE-36 and SE-39), during the late 1980s and the early 1990s, the number of silk-weaving enterprises in PTC might reach 300 (Interviews with the owner of SE-36, September 7, 2008 and with the owner of SE-39, September 19, 2008).

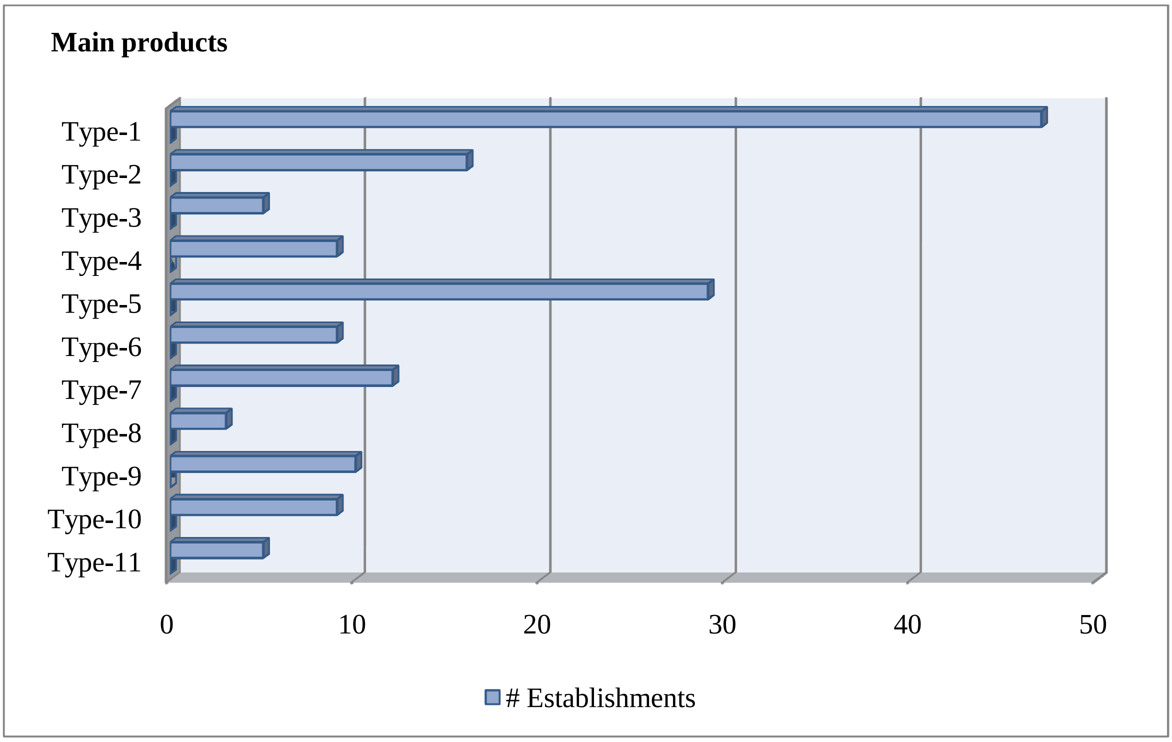
lines. As a result, PTC producers have to compete with each other in many product lines. For instance, in such product lines as plain fabrics (mainly supplying to the printing and clothing factories), geometric patterned fabrics, and Thai-styled *ikat*, the competition tends to be very intense because many producers have entered these markets (see Table 6.6 and Figure 6.5).

Table 6.6: Main products of PTC silk-weaving establishments

	Main products	**# Est.**
Type-1	Plain fabrics (light/middle/heavy weights of various colors)	47
Type-2	Geometric patterned fabrics	16
Type-3	Curtain and fabrics for decoration (heavy-weight fabrics)	5
Type-4	Bed cover, table cover, pillow cases	9
Type-5	Traditional Thai-styled *Ikat*	29
Type-6	Scarf, shawl (plain and patterned)	9
Type-7	Modern styled *Ikat*	12
Type-8	*Khit* fabrics	3
Type-9	Men & women cloths, including suits	10
Type-10	Traditional Thai dresses	9
Type-11	Neckties, bags, and silk accessories	5
	n = 53	

Note: (1) Main products = products that account for 90% or more of sales; (2) Multiple choices are allowed.
Source: Author's interviews

Figure 6.5: Main products of PTC silk-weaving establishments



Note: Product types are the same as in Table 6.6
Source: Author's interviews

Many establishments that are only specialized in producing plain-fabrics (especially light and middle weight ones), geometric patterned fabrics, and *ikat*, tend to face furious completion from both PTC producers as well as producers in other areas. As these products are easy to produce, the entry barriers are quite low. When more establishments chose to enter these product lines, they then suffered cut-throat competition and low profit margins. In fact, I found that most of establishments founded after 1985 relied on these product lines for at least 90% of their sales (see Appendix 6.1). Thus, they tend to suffer furious competition more than those establishments founded before.

During the interview, interviewees were asked to list the problems that their business encounters. The list of main problems is given in Table 6.6. The top three problems faced by

PTC silk-weaving establishments include price-dumping/cut-throat competition, increasing price of raw materials, and low price of silk fabrics. Price-dumping was viewed by the interviewees as the most important problem they had encountered.

b. Increase in prices of silk yarns

Aside from furious competition, another serious problem is the increasing prices of raw materials, especially silk yarn.[140] The structure of silk yarn industry in Thailand is very monopolistic: five silk-yarn producing firms occupy more than 80% of total product value (Wanwalee 2000). In PTC silk-weaving industry, the supply of silk yarn is monopolized by a few silk-yarn producers.[141] The monopoly in silk-yarn market – both local and national – has led to a sharp increase in silk-yarn price. For example, the price of warp yarn has increased about 100% from 700-800 baht per kilogram (depending on the quality) in 1998 to 1,400-

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[140] In silk-fabric production, silk-yarn accounts for about 60-70% of production costs. The rest is labor costs, chemicals and color, and others (e.g. electricity, water, etc), which account for about 15-30%, 5-10%, and 2-3%, respectively. Cost structure is determined by product type. For example, for plain fabric product silk-yarn and other costs together may account for about 85%, while labor may account for about 15%. But for *ikat* fabric, labor costs may as high as 25-30% depending on how complicated the work is (Interview with SE-21, (August 20, 2007)).

[141] In fact, there are only two silk-yarn companies that supply silk-yarn for PTC silk-weaving establishments: *Chun Thai Silk Co., Ltd.* (CTS) *and Badin Thai Silk Co., Ltd.* (BTS). CTS is located in Pechabun Province (about 220 km from PTC), while BTS is located in PTC district. CTS has a strong influence on silk-yarn market as it is the largest silk-yarn producer in Thailand. Its influence on PTC silk-weaving industry is also very strong. It has been supplying silk-yarn for PTC producers for more than two decades. In my interviews, all 53 establishments stated that they use silk-yarn from this company. And on average, each PTC producer buys about 70-80% of silk-yarn from this company. BTS is still very new for PTC's producers. This company was established in 2007. The main reason for its establishment is to compete with CTS in PTC silk market (as well as in other provinces in the Northeast) by offering alternative products with lower prices and same quality. This company imports varieties of silk-worm from China and hires three Chinese technicians to supervise its sericulture and yarn-reeling activities. It currently hires 70 workers in silk-reeling factory (Author's interview with the manager of *Badin Thai Silk Co., Ltd.*, September 16, 2008). However, at the time of my interviews, silk-yarn from BTS has not been widely used by PTC producers. Of the 53 establishments, only 22 buy silk-yarn from this company (while the manager of this company claimed that there are about 40 establishments in PTC that are her regular buyers). And among these 22 establishments, the percentage that each establishment buys from BTS is only 10-40%. It was mentioned by PTC producers that despite the prices of silk-yarns from BTS are slightly lower than that of CTS, BTS's silk yarns are not constantly supplied and their quality is still lower than CTS's silk yarns.

1,600 baht per kilogram in 2008. However, the price of silk fabric has increased only minimally during the same period. For example, the price of light-plain fabric increased from 17-18 baht per one yard to 22-24 baht per one yard (or increased about 29-33%) between 1998 and 2008.[142]

Thai government's policy on silk-yarn trade[143] is one of important factors which explain why the monopoly that has taken place. The original aim of the government was to protect sericulture agrarians and yarn producers at the household level by imposing a regulation on import of silk yarn. Based on that regulation, the importers of silk yarn have to buy domestic silk-yarn by the ratio of 2:1. That is, in order to import 10 kilogram of silk yarn, the importers have to buy 5 kilogram of domestic silk yarn. This policy limits the incentive to import and distort market mechanism. In fact, the real beneficiaries of this policy are not household producers but large yarn-producing firms. This is because, unlike large yarn producers, household producers produce only a small share of silk yarn for household usage or exchanges in local markets. Hence, they get little of the benefit of domestic silk yarn protection; instead it is the, large monopolized firms that benefit most.[144]

The protection of domestic silk yarn producers affects downstream producers directly, especially those undertaking silk-weaving activity. This is because silk yarn accounts for about 60-70% of the costs of silk fabric production. While the import of silk yarn is still

[142] Interview with the president of PTC Silk Association (September 4, 2008).
[143] Thai government's policy to control the imports of silk yarn can be traced back to 1953 when the government promulgated "the Royal Decree on the Import Control 1953". In this law, silk yarn was listed among the controlled goods. Based on the Royal Decree on the Import Control 1953, Ministry of Commerce declared the ministerial regulation on the import of silk yarn thread in 1976 which has been effective until recently (2008, by the time I conducted the interviews). According to this regulation, the importer of silk yarn must buy silk yarn from the domestic silk-yarn companies that are registered with the Ministry of Commerce in the ratio 1:2 (that is, to import two kilograms of silk yarn, the importers have to buy one kilogram of silk yarn from domestic silk-yarn companies) (Saksirisampan 2006).
[144] Interview with the president of Thai Silk Association (April 19, 2007).

restricted, the import of silk fabrics tends to increase continually.[145] As a result, the import of silk fabrics tends to increase at a higher rate than the import of silk yarn & thread. As shown in Figure 6.6, after the year 2000, the import of silk yarn & tread exhibits a slight rise, whereas the import of silk fabrics tend to show a faster increasing rate. Consequently, silk fabric producers, including PTC silk-weaving establishments, suffer from rising production costs as well as increased competition from imported fabrics. The president of PTC Silk Association explained the nature of the problem thus: "…The price of silk yarn has increased about 5-10% per year. About 10 years ago the price of warp yarn was only about 700-800 baht per kilogram, now it is 1,300-1,400 baht per kilogram. However, silk fabrics price has rarely changed. Ten years ago the price of lightest plain silk-fabric[146] was around 17-18 baht, now it is only 22-24 baht. We are now suffering skyrocketed silk-yarn prices and low silk fabric prices."[147]

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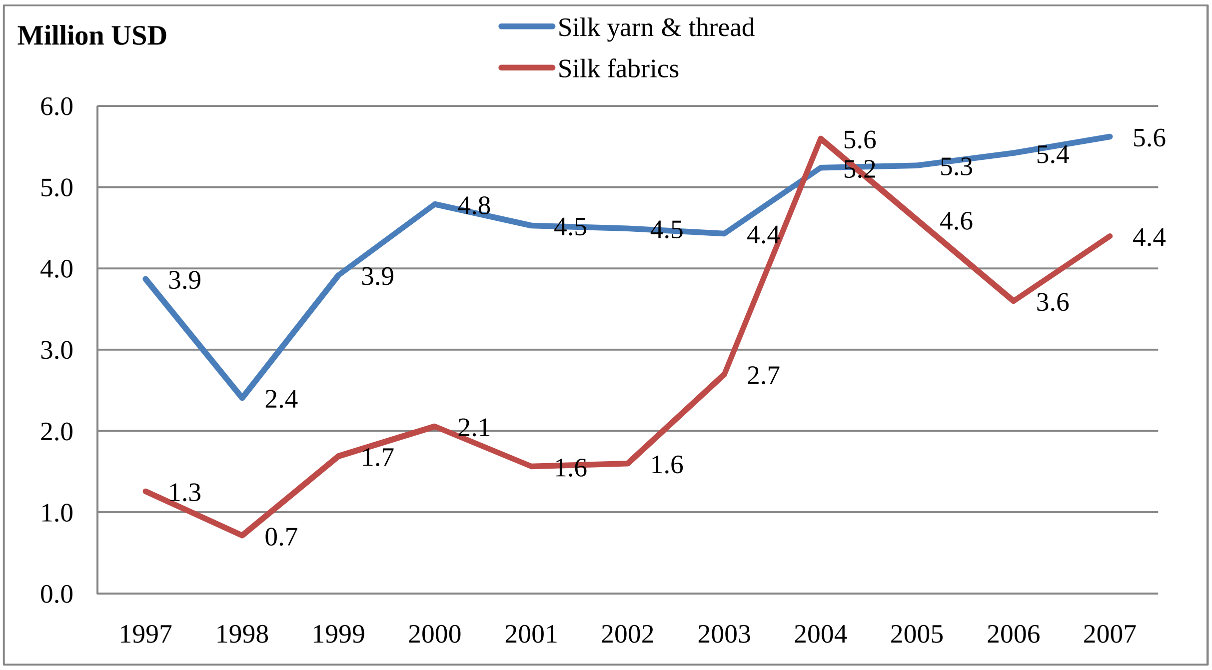
[145] The increase in silk fabric import is said to be caused by regional free trade agreements. Important regional free trade agreements which directly affect the import of silk fabrics are ASEAN Free Trade Area (AFTA) and China-ASEAN Free Trade agreement (Interviews with the president of Thai Silk Association (April 19, 2007) and the president of PTC Silk Association (September 4, 2008)).

[146] Lightest fabric refers to fabric woven by two threads (added by author).

[147] Interview with the president of PTC Silk Association (September 4, 2008).

Figure 6.6: Changes in import values of silk yarn & thread and silk fabrics, 1997-2007



Source: Ministry of Commerce (MOC) for the years 1997-2000 and Thailand Textile Institute (THTI) for the years 2001-2007

In sum, the increase in silk yarn price at a higher rate than silk fabrics leaves PTC silk-weaving establishments with small profit margins. As can be gauged from Table 6.7, the majority of them mentioned cut-throat competition, low price of fabrics, and increasing price of raw materials (silk yarn) as the main problems that they now encounter.

Table 6.7: Main problems that PTC silk-weaving establishments regularly encounter

	Problems	**# Est.**	**%**
1	Price-dumping/cut-throat competition	44	82.5
2	Lack of skilled or specialized labor	6	11.3
3	Lack of information on markets/market demands	24	45.0
4	Lack of information on new fashion and designs	19	35.0
5	No access to credit	8	15.0
6	Increasing price of raw materials	42	80.0
7	Low price of silk fabrics	38	72.5
8	Others (e.g. cheating, misbehavior of labor)	4	7.5
	n = 53		

Note: Multiple choices are allowed.
Source: Author's interviews

c. Low cooperation

Despite serious problems in terms of increased price of silk yarn and low price of silk fabrics, joint action among PTC silk fabric producers to collectively solve these problems has not yet taken place. Cooperative efforts to bargain the prices with silk-yarn producers and to set standard prices of silk fabrics are very modest and have had little impact.

Table 6.8 provides information about horizontal cooperation among the sample 53 silk-weaving establishments. In the in-depth interviews, the owners/managers of silk-weaving establishments were asked how often during the past three years they have cooperated with their neighbors to solve business problems or to share information which is necessary for improving business performance. It is found that cooperation is very rare or absent in every aspect. There are a few establishments that have *regularly* shared information on markets and customers/buyers, *regularly* cooperated for pricing of the products, and *regularly* shared the orders with their neighbors. In fact, these establishments mainly cooperate with their relatives who are in the same business. The majority of the sample establishments stated that they have *never* cooperated with any neighboring establishments in any aspect of cooperation; for example, *never* share any information on markets and buyers, product designs and pattern, and on labor force. Most of them have *never* made collective efforts to bargain with producers/sellers of raw materials, to set standard prices of silk fabrics, or to share the orders. Many establishment owners/managers said they have *rarely* done so.

Thus, intense competition leads PTC producers into relationships of rivalry. They view their neighbors as business rivals rather than business partners (except for those who have relatives operating silk-weaving business). Based on this view, information is kept as secret and joint action is not taken as strategic option, as one owner has mentioned: "Every establishment has its own secrets about markets and buyers and product designs. We have to keep those secrets as much as we can. A leak of important information to other establishments would ruin our competitiveness."[148]

[148] Interview with the owner of SE-18 (September 2, 2008).

Table 6.8: Horizontal cooperation with other silk-weaving establishments in PTC

	Forms of cooperation (during the past three years)	Frequency (# and %)				Total
		(1)	(2)	(3)	(4)	
1	Sharing information on markets and customers/buyers	3	12	8	30	53
		(5.7)	(22.6)	(15.1)	(56.6)	(100)
2	Sharing information and knowledge on product designs/patterns	0	4	12	37	53
		(0)	(7.5)	(22.5)	(70.0)	(100)
3	Sharing labor or information about labor	0	4	12	37	53
		(0.0)	(10.0)	(30.0)	(60.0)	(100)
4	Cooperation for buying/bargaining with producers/sellers of raw materials	0	5	16	32	53
		(2.5)	(5.0)	(12.5)	(80.0)	(100)
5	Cooperation for buying/bargaining with producers/sellers of machines/tools	0	0	7	42	53
		(0)	(0)	(5.0)	(95.0)	(100)
6	Cooperation for pricing of silk fabrics (or other products)	1	1	7	44	53
		(2.5)	(2.5)	(12.5)	(82.5)	(100)
7	Sharing the orders	1	3	11	38	53
		(2.5)	(5.0)	(20.0)	(72.5)	(100)

Notes: 1. For frequency, (1) = regularly; (2) = sometimes; (3) = rarely; and (4) = never. 2. The numbers in parentheses denote percentage.
Source: Author's interviews

It is fair to mention that there is some effort to solve the problems that PTC silk-weaving establishments commonly encounter. In 2000, the PTC Silk Association (PTC-SA) was established by PTC producers. The main objectives are to seek cooperation among members in order to solve business problems and to achieve business development together. At the time of my interviews (September 2008), there were 78 establishments that were the members of PTC-SA.[149] However, until recently PTC-SA has not had much success in bringing about collaborative efforts and joint action among its members. According to the president of PTC-SA: "Most of our members lack a good intention to solve the problems in

[149] In fact, all 53 sample establishments are the members of PTC-SA.

long-term. They join the association just for getting more purchasing orders and do not care much about long-term problems such as low price of products, high price of raw materials, and so on. Our original aim is not to bring in the orders and share to members, but to solve those problems. When they realize that they cannot get what they want, they no longer cooperate."[150]

Some small producers also blame a group of large producers who always serve as the administrative committee of the association. They think that benefits are only shared among these large producers and not shared with small producers. According to one owner: "..The association was established by them (large producers) and has been dominated by them. They only need our presence in order to show the buyers or government agencies to get more purchasing orders or financial supports. But when purchasing orders and supports come, we hardly receive those benefits. They just share among themselves. So, I stopped participating in the activities of PTC-SA."[151]

Antagonistic views on each other make the association unsuccessful in raising cooperative efforts and joint action from its members. Table 6.9 shows the frequency that our sample establishments have attended PTC-SA's activities during the past three years. It is shown that most establishments have rarely or never attended the activities. Only a minority group of establishments are regular attendants. From this information, it is possible to assume that, as the only mechanism available, PTC-SA is rather unsuccessful in fostering cooperative efforts and joint action among PTC silk-weaving establishments in order to solve the problems that their businesses have been facing in common.

[150] Interview with the president of PTC Silk Association (September 4, 2008).
[151] Interview with the owner of SE-14 (September 1, 2008).

Table 6.9: Frequency of attending PTC Silk Association's activities

Q: How frequent do you attend PTC Silk Association's activities during the past 3 years?	**Frequency** n	%
a. Regularly	10	18.9
b. Sometimes	15	28.3
c. Rarely	18	34.0
d. Never	10	18.9
Total	53	100.0

Source: Author's interviews

6.6.2 Relations with buyers

In the recent history of the PTC silk-weaving industry, relations between PTC silk-weaving establishments and their buyers can still be regarded as most important factor for an establishments' performance. In my interviews, the owners/managers of establishments were asked to identify important sources of information on product designs and on markets. These two kinds of information are very important for the performance of the establishment. Designs/patterns determine how well products will be accepted by customers of various tastes, while market information allows producers to correctly estimate market demands. Table 6.10 shows that, for most of silk-weaving establishments, an important source of information is the buyers. For example, 47 of 53 establishments mentioned that buyers are their main source of information about product designs and markets. Because buyers know what kind of products are demanded by the markets, what designs/patterns of silk fabrics should respond to each market segment, and how much silk fabrics are demanded by the markets, they can be the best source for product improvement.

Table 6.10: Sources of information about product designs and markets

			Frequency (#)	Frequency (%)
1	Information about product designs/pattern			
	Source:			
	a.	Buyers	47	88.9
	b.	Supporting institutions	9	16.7
	c.	Own efforts	32	61.1
	d.	Other PTC producers	6	11.3
	e.	Other sources	6	11.1
		n = 53		
2	Information about markets			
	Source:			
	a.	Buyers	47	88.9
	b.	Supporting institutions	6	11.1
	c.	Own efforts	45	84.9
	d.	Other PTC producers	9	17.0
	e.	Other sources	3	5.6
		n = 53		

Note: Multiple choices are allowed.
Source: Author's interviews

Apart from buyers, many establishments make their own efforts to improve product designs and to seek for market information. PTC producers rely on various methods to improve their product designs and obtain market information. These include: (1) subscribing to fashion or textile magazines; (2) attending fashion shows or textile exhibitions; and (3) attending study/training courses on fashion and designs provided by government agencies or private institution.[152] Learning from neighbors is not the case in PTC silk-weaving industry.

[152] Attending study/training courses on fashion and design is quite rare. Government agencies (such as PTC-OCD, NROIP, and THTI) regularly provide free training courses on fashion, designs, managements, etc. But these training courses are not particularly attractive for PTC producers (as can be seen from Table

As shown in Table 6.10, only six of the 53 sample establishments receive information on product designs from their neighbors and only nine obtain market information from this source.

Although most of the 53 sample establishments mentioned the importance of buyers as providers of information on product designs and markets, the roles that recent buyers take to help PTC producers upgrade or improve their performance are not equivalent to the roles played by JT to help its subcontractors under the previous subcontracting arrangements. This subsection and the following subsection discuss this issue.

Based on characteristics of buyer-supplier relations, buyers of PTC silk fabrics can be categorized into five groups: export agents, printing factories and garment producers, cloth shops, middlemen, and individual buyers. Each buyer plays a different role in helping PTC producers develop. Figure 6.7 summarizes the relations between PTC silk-weaving establishments and their current buyers. The figure also shows three modes of relations taking place in the interactions between PTC producers and buyers.

The first two groups of buyers include export agents and garment producers and printing factories. Usually, these buyers have their own designs which they may develop by themselves or receive from their buyers (such as foreign importers). When they order silk fabrics from PTC producers, they also give sample products with some description of product characteristics that they require. PTC producers are obliged to produce silk fabrics that meet

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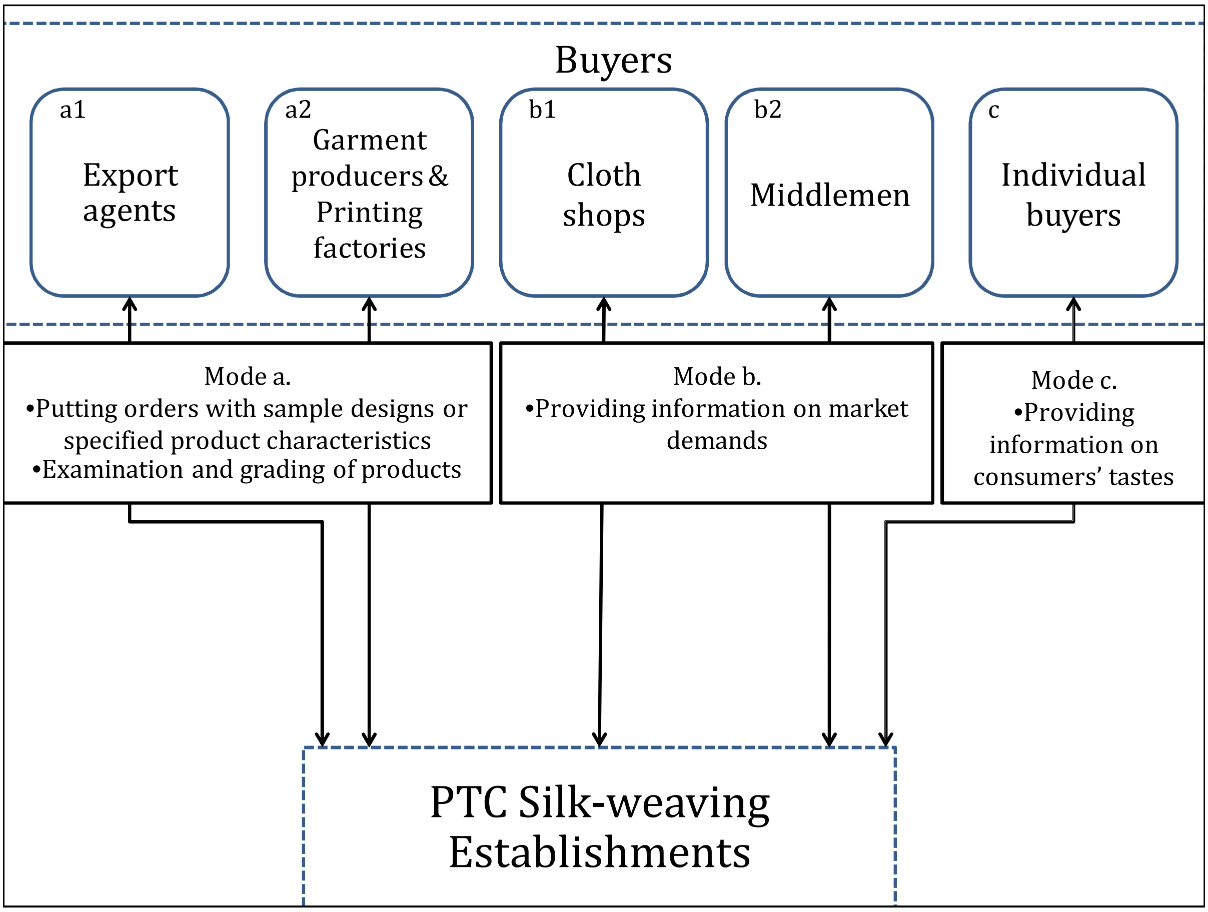
6.8 that only nine establishments mentioned the role of supporting institutions in proving information on product designs, and only six mentioned their role in providing market information). This is because PTC producers view that those training courses are not very useful for them. For example, information provided is outdated and is generally known. The cases of attending study courses provided by private institution are also very rare because the cost is very expensive. For example, according to the manager of SE-2, the tuition fee that he has paid for attending a six-month course of fashion design was 400,000 baht. Thus, of 53 establishments, only five have made efforts in attending study course on fashion and design provided by private institutions (SE-2, SE-4, SE-5, SE-26, and SE-29).

such requirements. The way to produce is totally left to PTC producers. The case of follow-up or supervision of production at producers' workplace was not found. When the products are delivered, these buyers will examine and grade products. They also provide comments and instructions for PTC producers, especially in case that there are some defects in the product. It can be said that through interactions with these buyers, PTC silk-weaving establishments can learn new product designs.

Figure 6.7: Relations between PTC silk-weaving establishments and their buyers



Source: Author's interviews

The second group of buyers includes cloth shops and middlemen. These buyers play a very limited role in helping PTC producers develop. Their role is limited to providing information on market demands. Normally, cloth shops and middlemen do not have knowledge and skills on product designs. They only concentrate on selling products. However, as they are closer to final product markets than PTC producers, they can provide PTC producers with general information about market demands (e.g., what style, what color, or what pattern is demanded by markets).

The last group of buyers is a group of individual buyers. This group includes small buyers (e.g. travelers) and large buyers (e.g. hotel, restaurant, furniture producers). These buyers do not have much knowledge about silk fabrics; they can just give information which reflects their tastes. Normally, PTC producers have to produce fabrics of various styles and put them in the showroom or in the catalog so that individual buyers can easily chose from sample products which are available. Thus, compared with the previous two groups, this group of buyers plays a very limited role in enhancing production capability of PTC silk-weaving establishments.

Although recent vertical linkages between PTC silk-weaving establishments and buyers are considered by most of the sample establishments as important sources for product improvement and business performance, these linkages are not as efficient as the linkages taken place between JT and its subcontractors. The roles of recent buyers are limited only to providing information about product designs, product quality, and market demands. Unlike JT, recent buyers do not have a mechanism that would help their PTC suppliers improve production technologies or develop new products. There are no cases of collaboration in product development process (e.g., production trial run), regular follow-up or close supervision on subcontractors' production processes, as carried out by JT.

6.6.3 Comparison of economic performance

This subsection shows that learning under JT's subcontracting arrangements helps some PTC silk-weaving establishments who used to be JT's subcontractors (JT's former subcontractors) perform better than those who did not (i.e. non-JT former subcontractors). To elaborate on this point, I compare some characteristics and performance of these two groups.

In Table 6.11, three groups of variables are used for comparison: owner's characteristics, establishment's characteristics, and establishment's performance. Two types of test statistic – the independent T-test and the M-W test – are used to test whether differences that exist between two groups of establishments with respect to each variable (except variables *formality* and *export*) are statistically significant.[153]

We can observe that current owners of two establishment groups are not significantly different in terms of age and experience. They are, however, significantly different in terms of years of schooling (with a weak statistical significance at 10% level): the owners of JT's former subcontractors are on average more educated than the owners of non-JT's former subcontractors. Generally, current owners of both establishment groups are of the same generation. The only difference is that most of current owners of JT's former subcontractor group inherited businesses from their parents who were the founders of the establishments,[154] while most of owners of the other establishment group are themselves the founders of the establishments. In terms of experience, the owners of JT's former subcontractors seem to enter silk business slightly earlier than the owners of non-JT' former subcontractors, though the difference is not significant. This is because the current owners of the first establishment

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[153] The independent T-test is used for variables that two sample establishment groups are at least roughly normally distributed; otherwise the M-W test is used, provided that two samples have similar shapes of distribution (Weiss 2005).
[154] Except SE-3, SE-6, and SE-8 whose current owners are also the founders of the establishments.

group started to get involved in silk-weaving industry by helping their parents right after they finished high school or university, while the owners of the second group entered the silk-weaving industry as wage workers before they accumulated skills and capital to start their own business. This also explains why average establishment ages between JT's former subcontractors (39.1) and non-JT's former subcontractors (18.3) are significantly different (at 1% level), indicating that the former were established long before the latter.

Most of non-JT's former subcontractors tend to operate in the informal sector, though their average establishment size of about 30 employees is not particularly small. They can do so because they put out most of production processes to home-based weavers. On the other hand, as JT's former subcontractors tend to concentrate production activities in their factory, they have to formally register their establishment.

In terms of economic performance, the differences between two establishment groups in terms of employment and output are not statistically significant. This is because PTC silk-weaving industry in general had been facing economic recession by the time that in-depth interviews were conducted (i.e., August-September, 2008). Most of the owners/managers whom I interviewed mentioned that their purchasing orders have been reduced in recent years, causing a reduction in employment, output, and sales. Although both establishment groups have recently been faced with business recession, the advantages of having used to involve in JT's subcontracting arrangements cannot be ignored. First, JT's former subcontractors enjoyed much higher sales than their counterpart. Average sale of JT's former subcontractors is 756,548 baht (approximately, $22,416 US) per month, whereas average sale of non-JT's former subcontractors is 519,815 baht (approximately, $15,402 US) per month (the difference is statistically significant at 5% level). Thus, although employment and output are not significantly different between these two groups, sales are; this indicates that silk-fabrics produced by JT's former subcontractors are more expensive than those produced by their counterpart.

Table 6.11: Comparison of JT's former subcontractors and non-JT's former subcontractors

Variables	**JT's former Subcontractors** ($\bar{x}_1$)	**Non-JT's former Subcontractors** ($\bar{x}_2$)	**Test statistics**	
			T-test	**M-W test**
Owner's characteristics				
1. Owner's Age	49.4	50.8	0.39(0.696)	-
2. Years of schooling	11.7	8.4	-1.85(0.079)[c]	-
3. Experience (years)	28.8	23.8	-1.05(0.307)	-
Est.'s Characteristics				
4. Est.'s age (years)	39.1	18.3	-6.77(0.000)[a]	-
5. Formality [1]				
Yes	13(100%)	14(35%)		
No	-	26(65%)		
Performance				
6. Labor(L) [2]	22.8	30.0	-	193.0(0.958)
7. Output(O) [3]	3,062	2,783	-	146.0(0.195)
8. Sales(S) [4]	756,548	519,815	-	116.0(0.037)[b]
9. Profit [5]	191,781	69,460	-	67.0(0.000)[a]
10. Profit margin (%)	28.2	13.6	-	56.5(0.000)[a]
11. Labor productivity(O/L)	133.6	99.5	-	96.5(0.008)[a]
12. Labor productivity(S/L)	33,144	19,739	-	61.0(0.000)[a]
13. Export				
Yes	9(66%)	8(20%)		
No	4(31%)	32(80%)		
Sample size = 53 (Total)	13	40		

Notes: (1) Superscripts 1 = formal status of the establishments acquired by official business registration; 2 = number of persons that establishments currently employed; 3 = average silk fabrics in yard per month; 4 = average sales in baht per month; and 5 = average profit in baht per month. (2) The numbers in column 2 and 3 are mean values of variables, except those for variables *formality* and *export*. (3) The numbers in column 4 and 5 are the critical values and P-values (in the parentheses) of T-test and M-W test. (3) Superscripts a, b, and c denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Author's interviews

Second, JT's former subcontractors perform better than their counterpart in terms of labor productivity. Here, labour productivity is calculated based on two measures: monthly output by labour and monthly sales by labour. As shown in Table 6.11, labour productivity is higher for JT's former subcontractors in both measures, which indicates that they produce silk fabrics more efficiently than their counterpart.

It should be noted that their higher output per labour (O/L) is due to more efficient work organization rather than utilization of superior technologies such as electronic looms. In fact, electronic looms used in both groups are quite similar. Of 53 sample establishments, electronic looms are used by seven establishments of which two are JT's former subcontractors (SE-4 and SE-5) and five are non-JT's former subcontractors (SE-15, SE-22, SE-23, SE-26, and SE-44). The total number of electronic looms is 20 for JT's former subcontractors and 24 for non-JT's former subcontractors. Thus, higher output per labor (O/L) of JT's former subcontractors does not seem to be associated with using electronic looms. I would argue that higher output per labor (O/L) is due to more efficient organization of work: while the JT's former subcontractors mainly use the factory system, non-JT's former subcontractors rely on the putting-out system. As it is difficult to supervise homeweavers who work at their own premises, outputs produced under the putting-out system tend to be lower than those produced under the factory system. While non-JT's former subcontractors said their homeweavers can produce about 90-120 yards of silk fabrics per month, JT's former subcontractors claimed that their factory workers can produce about 180-200 yards per month.

When productivity is measured as sales per labour (S/L), large difference also exists: JT's former subcontractors are more productive than non-JT's former subcontractors (the difference is statistically significant at 1% level). I argue that higher sales per labor (S/L) of the former are due to their production of better-quality and more expensive products. As can be seen from Table 6.10, products of JT's former subcontractors are more profitable; their profit and profit margin are higher than their counterpart (with strong statistical significance at 1% level). For example, for JT's former subcontractors, of every 100 baht of sales, about 28 baht is a profit; however, for non-JT' former subcontractors, only 13.6 baht of 100 baht sales is a profit.

Finally, in terms of export, 9 of 13 JT's former subcontractors (66%) have been able to establish themselves in export markets which are generally more profitable than domestic markets, while only 8 of 40 non-JT's subcontractors (20%) can do so. Exports are one of main factors which explain why JT's former subcontractors enjoy more sales and profits than their counterpart. Export markets are considered by PTC silk-weaving establishments as more profitable than domestic market.[155] It requires higher-quality products and more sophisticated designs. According to one owner who exports more than 50% of his product, profit margin of export product is about 30-50%, depending on product types.[156] As a larger number of JT's former subcontractors export their products, their sales and profits are higher than those non-JT's former subcontractors. But to be able to export their products, their learning under JT's subcontracting arrangements must have played a significant role, as previously mentioned.

It is likely that JT's former subcontractors perform better than non-JT's former subcontractors not because they have entered the market earlier. To test this proposition, I divided 40 non-JT's former subcontractors into two groups based on establishment ages. The first group (Group 1) consists of silk-weaving establishments founded in 1987 or earlier, and the second group (Group 2) consists of those founded after 1987. Then, I compared these two groups with 13 JT's former subcontractors in terms of business performance, based on the

[155] Note that all PTC exporters export their product through export agents.
[156] Interview with the owner of SE-26 (August 23, 2007).

procedures performed for Table 6.11. The results are provided in Appendix 6.2.

The results reveal that establishment ages do not seem to explain the better performance of JT's former subcontractors. When JT's former subcontractors are compared with Group 1 establishments (Panel a. of Appendix 6.2), the results are still similar to those in Table 6.11. That is, JT's former subcontractors perform better in every indicator, except in employment (the number of labor employed). When comparing JT's former subcontractors with Group 2 establishments (Panel b. of Appendix 6.2), we find that the former are still better-off in terms of profits, profit margins, and labor productivity. Finally, when we compare Group 1 with Group 2 (Panel a. of Appendix 6.2), it is found that Group 2 performs better than Group 1 in most of performance indicators. In other words, younger establishments are doing better than older establishments. Therefore, age does not seem to explain the better performance of JT's former subcontractors over those non-JT's former subcontractors. It is the learning that took place when they were involved in a long-term subcontracting relationship with JT that matters.

In sum, JT's former subcontractors, on average, enjoy more sales, profits, and labor productivity than their counterpart, non-JT's former subcontractors. Based on this information, it can be argued that JT's subcontracting arrangements are helpful for improving economic performance of its subcontractors. The case study of PTC silk-weaving industry has shown that vertical inter-firm linkages and collective actions between co-located buyer and subcontractors are important for the upgrading and development of the latter.

Before ending this section, I would argue that the findings in this chapter have some implications for findings in Chapter 5. What we have found in Chapter 5 is that the spatial clustering of 2-digit industry is positive for establishments' labor productivity, whereas the clustering of 3-digit or 4-digit industries tends to be negative for labor productivity. This implies that the agglomeration of establishments taking different but related activities is better for productivity improvement than the agglomeration of establishments taking the same activities. As revealed in this chapter, PTC producers (13 JT's former subcontractors) concentrated on silk fabric production and linked their activity with JT's downstream activities such as printing, clothing and garment making. In this case, it is likely that knowledge and information that flow within the linked production processes contribute to productivity improvement. On the other hand, without vertical linkages with co-located buyers, PTC fabric producers have come to compete intensely with each other because most of them produce similar products. This is not conducive for their productivity improvement, especially when the competition is based on price rather than quality or designs of products.

6.7 Conclusion

This chapter has attempted to answer the research question: what are the mechanisms through which industrial clustering may contribute to the improvement of manufacturing establishments' performance? The analysis in this chapter is based on a case study of silk-weaving industry in PTC district. The main findings in this chapter are as follows.

First, in PTC silk-weaving industrial cluster, there are some establishments that can stay robust and some others that cannot. The data derived from in-depth interviews with the owners/managers of PTC silk-weaving establishments indicates that vertical inter-firm relations between a group of PTC producers and their buyer (*Jim Thompson* - JT) under long-term subcontracting arrangements are significant for the development of the former. However, for such vertical inter-firm relations to be powerful in improving establishments' performance, regular face-to-face interactions and close supervision that take place in every stage of the production process are necessary. Co-location of subcontractors and buyer allow these to take place. This finding is rather consistent with the *collective efficiency* framework: industrial clustering in terms of spatial and sectoral agglomeration *per se* is not sufficient to explain the development of manufacturing establishments. To upgrade and stay robust, establishments need collaborative efforts and joint action. JT's subcontracting arrangement was conducive for the upgrading of 13 subcontractors because it was based on regular face-to-face interactions in every process of production, which allowed for information exchanges and knowledge transfers to take place. Although vertical inter-firm linkages between PTC silk-weaving establishments and their buyers have also come to exist in recent years, the degree to which recent buyers are involved in subcontractors' production process is much less than JT's involvement.

Second, intense competition and hostile relationship among establishments in the cluster prevents collaborative efforts and joint action from taking place. Consequently, the problems that establishments commonly encounter cannot be solved. In our case, PTC silk-weaving establishments which produce similar products tend to compete harshly with each other. They even rely on a cutting-profit-margin strategy in order to win purchasing orders. Such cut-throat competition leads establishments to view each other as rival rather than partner. Consequently, despite serious problems in terms of increasing price of silk yarn and low price of silk fabrics, there is an absence of collective efforts to solve such problems.

Chapter 7

Conclusion

7.1 Introduction

The topic of industrial clustering has gained an increasing interest from both academics and policy makers in recent years. As a real-world phenomenon, industrial clustering takes place in every part of the world. Instead of spreading all over space, industries exhibit spatial concentration at various geographical levels: international, national, and regional. Given that the phenomenon of industrial clustering can be widely observed, the basic question to ask is why industries are geographically clustered. This question leads to theoretical and empirical studies on the causes of industrial clustering. Those studies try to find factors that explain geographical agglomeration of industries. At the same time, development and policy research has seen industrial clustering as a driver for development. It is hoped that spatial agglomeration of industries may help to increase employment, wage, output, and productivity at firm, regional, and national levels. Thus, a number of development studies have particularly focused on examining the effects of industrial clustering.

Despite a growing number of studies on the causes and effects of industrial clustering in recent years, there are still some controversial issues and gaps in the existing body of literature. First, there is still debate in the literature over the issue of what kind of clustering is better for firm or regional performance. Specifically, there is an on-going debate over whether localization economies (i.e. spatial agglomeration of firms in the same sector) or urbanization economies (i.e. spatial agglomeration of firms from different sectors) is the most conducive type of clustering for helping firms and regions to develop.

Second, there have been few studies (e.g. Rigby and Essletzbichler 2002; Mare and Timmins 2006; and Baldwin et al. 2008) investigating spatial and sectoral extents at which the effects of clustering may take place. Specifically, the existing literature on the effects of industrial clustering has not yet successfully established at what spatial or sectoral scope that clustering is most conducive to the development of firms and regions. Industrial clustering may take place at various spatial scopes (e.g. district, city, region, or nation) or various sectoral scopes (i.e. at 2-dit, 3-digit, or 4-digit levels). In this case, it is worth investigating the spatial and sectoral scopes at which industrial clustering is most conducive to development.

Finally, the literature on industrial clustering has focused more on studying the modern industrial clusters in urban areas. Less attention has been paid to studying industrial clusters taking place in rural areas. So far, there are few studies (Sandee 1998; Weijland 1999; Sato 2000; Sandee and Rietveld 2001) investigating whether and how industrial clustering helps rural-based establishments improve their economic performance.

In this study, I took these issues into account. The current study answered three main research questions. First, *what determines spatial clustering of manufacturing establishments?* Second, *what are the effects of industrial clustering on manufacturing establishments' performance?* And third, *what are the mechanisms through which industrial clustering may contribute to the improvement of manufacturing establishments' performance?*

To address these research questions, I relied on both quantitative and qualitative analytical methods. The main data used for quantitative analysis are the Thai manufacturing industrial censuses 1997 and 2007 which reported the characteristics of the population of Thai manufacturing establishments existing at the end of 1996 and 2006, respectively. To answer the first research question, the binary logistic regression was used to analyze the model that dependent variable is a categorical variable taking two possible outcomes (e.g., an establishment are *located* in an industrial cluster or *not located* in an industrial cluster). To answer the second research question, the two-stage least square (2SLS) regression was applied to the models in which establishment's labor productivity is taken as a dependent variable. To answer the third research question, the case-study analysis was used. Silk-weaving industry in Pak Thong Chai (PTC) districts of Nakhon Rachasima (NR) province was selected as a case study. PTC is well known in Thailand for its specialization in silk-fabric production. In-depth interviews with 53 owners/managers of PTC silk-weaving establishments were conducted in August-September 2007 and 2008.

The conceptual framework used in this study is based on the *Marshallian localization* approach and the *collective efficiency* approach. Marshallian localization thesis posits that when firms in the same sector are geographically clustered, it generates positive externalities in terms of labor pool, specialized suppliers, and knowledge spillovers. However, collective efficiency approach argues that Marshallian externalities are not sufficient for firms to grow or remain competitive, because in the cluster itself there are some firms that are competitive and some others that are not, despite agglomeration externalities available to all of them. To grow and remain competitive, firms need *joint action*. To some extent, they need to actively collaborate with each other either to solve problems they collectively encounter or to achieve collective goals.

The main findings from this research, policy implication, and future research issues are discussed in Sections 7.2, 7.3, and 7.4, respectively.

7.2 Key findings

7.2.1. Dynamics of industrial agglomeration

Spatial distribution of Thai manufacturing has changed over time but the change varies across industries. Thai manufacturing industries were concentrated in the Bangkok Metropolitan Region (BMR) for several decades. However since 1985, the degree of concentration has begun to change. Manufacturing establishments started to relocate or were newly established in other areas. However, they still did not go far from the BMR. Mostly, they moved to the outer ring area - the area contiguous with the BMR - due to some advantages of this area such as proximity to Bangkok, well-developed infrastructures, and government-provided incentives. By the mid-1990s, large-scale and nation-wide industrial decentralization started to take place. The last decade has observed an increase in the share of manufacturing establishments in peripheral areas. Thus, it can be argued that, in general, Thai manufacturing industry has moved toward more dispersed geographical distribution over time. Nevertheless, there are some variations in the dynamics of geographic concentration among manufacturing sectors: the resource-based and labor-intensive industries registered a faster rate of dispersion and moving toward equal regional distribution more quickly than the machinery sector.

This finding is in line with the argument made by Fujita (2007) that resource-based and labor-intensive industries will tend be more dispersed across space than the technology-intensive industries. According to Fujita (2007), once the degree of industrial agglomeration in an urban area increases further, agglomeration costs will outweigh its benefits; then, industries will start to move out from the urban center to the locations where the costs are cheaper (e.g. lower land prices, cheaper labor costs, and less congestion). However, the technology-intensive industry tends to exhibit a slower industrial decentralization process than resource-based and labor-intensive industries. Unlike resource-based and labor-intensive firms, the primary concern of high-technology firms is about the availability of highly skilled workers and the benefits from knowledge spillovers arising from large agglomeration. Empirical studies (e.g. Brulhart 1998; Haaland et al. 1999; He 2009; and Kuncoro 2009) find evidence that support Fujita's (2007) argument. In this study, I added more evidence that support the ideas generated by Fujita (2007). In the case of Thai manufacturing industries, although spatial decentralization has taken place in every industrial sector, the rate of decentralization is relatively slow in such technology-intensive sectors as electronics, electrical machineries, and motor vehicles, as compared to other sectors.

7.2.2. Drivers of industrial clustering

To investigate the pattern of spatial clustering, I selected three industries as case studies, including motor vehicles, foods & beverages, and textiles industries. The index of plant density was used to measure the spatial clustering in these industries. The density of establishments in the BMR was used as the threshold to identify industrial clusters in other provinces. The results from this analysis reveal that in all three selected industries, the BMR is the only industrial cluster in Thailand. However, in each industry, there exist some provinces outside the BMR that exhibit a trend toward the formation of industrial clusters. For example, in the motor vehicle industry, the number of motor vehicle establishments increased significantly in four provinces (i.e. Ayutthaya, Chon Buri, Chachoengsao, and Rayong) between 1996 and 2006. In the textile industry, the provinces in the middle part of the northeastern region (e.g Khon Kaen, Roi Et, Kalasin, and Maha Sarakham) registered a large increase in textile establishments during the same period. Similarly, in the food products and beverage industry, the number of establishments increased rapidly in peripheral provinces.

The provinces that exhibited a large increase in the number of establishments are called "emerging clusters" to signify their movement toward becoming industrial clusters in the future.

What determine spatial clustering of manufacturing establishments? To address this research question, two establishments' location analyses were conducted: the first analysis examines the determinants of establishments' decision to be located in the BMR (as an industrial cluster), while the second analysis examines the determinants of establishments' decision to be located in the emerging clusters. The propose of dividing the analysis of establishments' location in the cluster from that in the emerging clusters is to distinguish the factors that contribute to the existence of industrial clusters from those that contribute to the formation of industrial clusters. (Note that establishments' decision to be located in the emerging cluster can be regarded as the formation of an industrial cluster).

Two types of the model were developed to estimate establishments' location: one taken establishments' location in the BMR as a dependent variable, and another one taken establishments' location in emerging clusters as a dependent variable. The binary logistic regression was employed as the estimation method. The main results are as follows.

First, in the analysis of establishments' location in the BMR, it is found that large-size and skills-intensive establishments are inclined to choose the BMR as their location. This notion holds for all three selected industries. For other establishment-level variables, their effects vary across industries. For example, in motor vehicle industry, foreign-owned establishments are more likely to be located in other areas than in the BMR, but in the foods & beverages industry, foreign-owned establishments are more likely to be located in the BMR than in other areas. In the motor vehicle and textile industries, vertically integrated establishments are more likely than those vertically disintegrated establishments to choose the

BMR as their production site, but in the food and beverage industry, vertically disintegrated establishments tend to be located in the BMR more than vertically integrated establishments.

There are some regional factors that explain why many manufacturing establishments choose to be located in the BMR. First, the BMR has a large pool of labor. As the BMR is the largest and most urbanized area in the country, its population contains a large number of people of working age that can match the need of manufacturing establishments. Second, not only does the BMR have a large number of population of working age, it also contains a large number of skilled workers. The availability of skilled workers explains why many manufacturing establishments still find the BMR suitable for their production location. Finally, the presence of previous industrial agglomeration in the BMR works as the driver of current agglomeration. Many establishments tend to be located in the BMR because it has a large number of pre-existing establishments. This is consistent with the idea generated by the New Economic Geography (NEG) school of thought that when agglomeration takes place, it tends to expand further. This is because large agglomeration generates a large demand for both inputs and final products which helps firms to reach scale economies. This notion holds in case of the BMR.

Second, in the emerging clusters analysis, each industry reveals different factors determining establishments' decision to be located in emerging clusters.

- In the motor vehicle industry, it is found that large, foreign-owned, export-oriented establishments employing more skilled workers are inclined to be located in emerging clusters (i.e. Chon Buri, Chachoengsao, Rayong and Ayutthaya). The presence of many industrial estates in these provinces as well as a large number of skilled workforce also work as the pull factors that attract many motor vehicle establishments to these provinces. Additionally, as these provinces have some advantages in terms of modern infrastructures, export-import facilities, and proximity to the BMR, those export-oriented foreign establishments find it worthwhile to be located there. Note that in this industry, I treated Chon Buri, Chachoengsao, Rayong and Ayutthaya as a separate region from the BMR in order to specifically examine the factors that contribute to the relocation of motor vehicle establishment to these four provinces. Having admitted that the motor vehicle industry in these four provinces is very well connected to that in the BMR (e.g., many establishments in these four provinces are part suppliers of large automobile assemblers in the BMR), I ran a separate analysis treating the BMR and Chon Buri, Chachoengsao, Rayong, and Ayutthaya as the same industrial cluster. The results were as theoretically expected: establishments are attracted to this cluster because of its locational advantages in terms of well-developed infrastructure, large labor pool, availability of skilled workforce, and agglomeration economies generated by the agglomeration of pre-existing establishments.

- In the food products and beverages industry, establishments that are attracted to emerging clusters tend to be small, Thai-owned, domestic market-oriented, and less-skilled establishments. It is found that the most important factor determining the decision of food and beverage establishments to be located in emerging clusters is the provincial share of resource-based sector in the gross provincial product (GPP) (e.g. agriculture, fishery, and forestry). This is not beyond our expectation: as foods and beverages industry is one of the typical resource-based industries, food and beverage establishments tend to go to the provinces where they can utilize resources needed. Based on this finding, we can conclude that, in the case of the Thai food and beverage industry, the most important factor explaining the formation of food and beverage clusters is the resources available in each province that can be used as raw materials in food and beverage production processes.

- In the textile industry, the location of textile establishments in emerging clusters is explained by the availability of cheap labor force. Textile establishments that tend to be located in emerging clusters consist of small establishments employing unskilled labor and only producing for domestic markets. It is shown in the model that the increase in the provincial share of skilled labor force tends to disperse establishments away from emerging clusters. This evidence implies that low skilled and cheap labor force is the primary concern for textile establishments located in those provinces. Thus, in the case of Thai textile industry, the most important factor explaining the formation of textile clusters is the availability of cheap labor in each province.

The findings in this study inform the existing literature on industrial agglomeration as follows. First, based on the resource-based approach (see Ohlin 1933; Ellison and Glaeser 1997, Brulhart 1998; Ellison and Glaeser 1999; Roos 2005), we have found that the so-called *first nature* matters in the case of Thai manufacturing industrial location. As predicted by the resource-based theory, the economic activities will be agglomerated in regions with relatively large endowment in specific resources (e.g. natural resources, labor, and capital); and the industrial location will be determined by the main resources used in each industry (Brulhart 1998). In our case, we have observed that this argument is relevant. For example, the location of food products and beverage industry tend to be determined by the share of such resource-based sectors as agriculture, fishery, and forestry in the GPP.

In addition, the findings in this study also indicate that resources necessary for a particular industry are different, depending on the types of activities carried out by establishments as well as the establishments' strategies. As this study has shown, it is still possible to see a high concentration of textile establishments in the BMR, despite high congestion costs in this region. Textile establishments in the BMR tend to be large establishments employing more skilled labor, while textile establishments in the emerging clusters tend to be small establishments employing unskilled labor. Thus, the location of establishments carrying out routine activities and undertaking a price-based competition strategy is different from the location of establishments producing differentiated products and undertaking product differentiation strategies (Kittiprapas and McCann 1999, p.42). Therefore, the analysis of industrial location based on the resource-based view may need to take into account such issues as types of activities establishments undertake or competitive strategies they pursue.

Second, the existence of an industrial cluster (the BMR) is determined by such agglomeration forces as scale economies and market demands, as suggested by the NEG School (Krugman 1991a; Krugman 1991b; Fujita 2007). The existence of industrial concentration in the BMR can be explained by Fujita’s (2007) *circular causation*. That is, when manufacturing agglomeration takes place in a particular area, it will attract more establishments and labor and generate greater market demands for input and final products; as a result, establishments will attain economies of scales. The process of agglomeration reinforces itself until congestion costs outweigh agglomeration benefits (Fujita 2007). We have observed that the agglomeration of establishments in the BMR in 2006 was determined by its level of agglomeration in 1996. We have also found that manufacturing establishments that are more sensitive to high congestion costs in the BMR have relocated to other areas. In the textile industry, for example, while large establishments employing more skilled labor are still located in the BMR where they can easily find skilled labor, those small establishments employing unskilled and cheap labor are attracted to other areas. Thus, in general, this study finds evidence to support the NEG’s thesis of industrial agglomeration.

7.2.3. Industrial clustering and labor productivity

Does industrial clustering help improve establishments' performance in terms of labor productivity? There has been a debate over this question. Evidence that industrial clustering is relevant for productivity seems to vary depending on the forms of agglomeration. Two schools of thought offer different ideas and evidence on the productivity effects of industrial clustering. The *localization economies* school argues that geographical agglomeration of firms in the *same* sector matters for productivity, as knowledge is easily transferred when firms share some basic understanding on products and production techniques. On the other hand, the *urbanization economies* school maintains that geographical agglomeration of firms from *different* industrial sectors is more conducive to productivity improvement, as it facilitates the exchange of different knowledge, which is a source of new ideas and innovations.

Apart from localization versus urbanization issue, it is argued that the effects of industrial clustering on establishments' labor productivity might somehow depend on industrial and geographical scopes of agglomeration (see Rosenthal and Strange 2004). In order to examine this issue, I divided the industrial agglomeration into six categories based on industrial and geographical units of measurement as follows: 2-digit provincial industry, 3-digit provincial industry; 4-digit provincial industry; 2 digit-subregional industry; 3-digit subregional industry; and 4-digit subregional industry.

In the econometric model estimating labor productivity of manufacturing establishments, I assumed that labor productivity is the function of localization economies, urbanization economies and some other control variables including regional industrial completion, establishment's import and exports, foreign investment, and ownership structure. Localization and urbanization economies variables are measured at six levels as just described. By modeling this way, I expected to see the separate effects of localization and urbanization economies taking place at different sectoral and spatial scopes.

The 2SLS regression method was employed for estimating the models with endogenous variables. The main results from this analysis are as follows.

- Localization economies (i.e. *spatial agglomeration of establishments in the same sector*) significantly contribute to establishments' labor productivity improvement. However, it is found that positive effects of localization economies only arise in the case of spatial agglomeration at 2-digit industrial level. For the spatial agglomeration at 3-digit and 4-digit levels, localization effects are rather negative. This finding indicates that spatial and sectoral agglomeration of manufacturing establishments operating in a broader range of production activities helps increase the labor productivity, whereas spatial and sectoral agglomeration of establishments operating in a narrow range of activities tends to decrease labor productivity. This finding holds across spatial units of analysis. That is, at both provincial and subregional levels, the effects of the *same-sector* agglomeration are only positive for 2-digit agglomeration and negative for 3- and 4-digit agglomerations.

- The effects of urbanization economies are negative in all spatial and sectoral settings. In this study, urbanization economies are defined as the spatial agglomeration of manufacturing establishments from different sectors. Hence, urbanization economies variables capture the diversity of regional industrial structure. Until recently, there has been no specific explanation as to why industrial diversity may lead to a decline in labor productivity. However, it is established that in a large urbanized area where various types of activity are densely agglomerated, it leads to high congestion costs (e.g. increased labor costs, land costs, and commuting time) which may outweigh the benefits of urbanization. I further investigated this issue and found that negative effects of urbanization variable tend to be predominant in the provinces with a very high density of manufacturing establishments. This indicates that negative effects of *different-sector* agglomeration (or industrial diversity) on establishments' labor productivity are largely explained by high congestion costs associated with increased urbanization.

It should be noted that the current study adds some empirical evidence (i.e. the case of Thai manufacturing industries) that supports the Mashallian externalities (or localization economies) thesis which maintains that agglomeration of establishments in the same industry matters for productivity improvement. The negative effects of urbanization economies found in this study run counter to the so-called Jacobian externalities which argue for the existence of positive effects generated by large urban areas having diversified industrial structure (Jacobs 1969; Sveikauskas 1975; Glaeser et al. 1992; Rosenthal and Strange 2003).

The positive effects of localization economies found in this study are consistent with those found in Nakamura (1985), Mare and Timmins (2006), and Martin et al. (2008). However, we have observed that the effects of localization economies are not always positive. Rather, they can be negative in the case of spatial agglomeration of narrow-range production activities. This means that scopes of agglomeration matter. Therefore, the current study indicates that in order to clearly understand the effects of industrial clustering on productivity improvement, it is important to take spatial and sectoral scopes of agglomeration into account. So far, there have still been relatively few studies in this area (notable studies include Rosenthal and Strange 2003, Baldwin et al. 2008, Brown and Rigby 2009).

7.2.4. Industrial clustering mechanisms relevant for establishments' performance

Having known the effects of industrial clustering (i.e., *same-sector* agglomeration), the next question to address is: what are the mechanisms through which industrial clustering may contribute to the improvement of manufacturing establishments' performance? This question has been answered by a case-study analysis of PTC's silk-weaving industry. In-depth interviews with owners/managers of 53 silk-weaving establishments revealed that vertical inter-firm relations under subcontracting arrangements between the buyer and subcontractors who are co-located is important for the upgrading and improved economic performance. I have examined the case of subcontracting arrangements between Jim Thompson (JT) – the largest silk firm in Thailand – and its 13 former subcontractors in PTC and found that JT's subcontracting arrangements helped those subcontractors upgrade their products and production processes.

Before 1967, the characteristics of the rural silk-weaving industry in PTC were as follows. First, silk-fabric production was undertaken by rural households as their off-farm activities for use in the household or for sale in the local markets. Second, although there were some local entrepreneurs who undertook silk-weaving activities on a commercial basis, they still relied on traditional methods of production. Those entrepreneurs relied on the putting-out system, used traditional production technologies, and sold their products mainly in the local markets. They produced a small quantity of silk fabrics with limited ranges of patterns and designs. However, when some local entrepreneurs become the subcontractors of JT in 1967, the upgrading of their products and production processes took place. First, with the assistance from JT (e.g., JT provided low-interest loan for building or expanding the factory), subcontractors substituted the putting-out systems with the factory system because the latter was more effective for quality controls. Second, they acquired more advanced machines/tools (e.g. the flying-shuttle looms and the electronic spinning machines), with the introduction and assistance from JT. Third, subcontractors were provided with new knowledge on yarn dyeing, silk weaving, and quality controls. Finally, subcontractors produced silk fabrics with a large variety of designs and patterns introduced by JT.

Upgrading occurred through certain mechanisms established by JT. First, JT sent its technicians to subcontractors' workplaces to work closely with subcontractors in the process of product development. Second, its technicians were obliged to visit subcontractors regularly in order to supervise production processes, follow up the jobs, and solve problems that occurred in the production processes. Finally, it gave detailed feedback and guidelines to its subcontractors which helped subcontractors to learn to improve product quality and standard. These mechanisms worked quite well because both JT and subcontractors were located in PTC district. Co-location allowed for regular face-to-face interactions to take place. And regular face-to-face interactions, in turn, facilitated information exchanges between JT and its subcontractors, and also facilitated technology transfers from JT to its subcontractors. As a result, subcontractors enjoyed long-term growth (e.g. sales and employment growth) while they were involved in subcontracting arrangements with JT.

However, after JT's subcontracting arrangements have ended during the late 1990s, there have been no vertical inter-firm linkages that are efficient enough to help PTC producers sustain their growth and competitiveness. Despite vertical linkages between PTC producers and their recent buyers, these linkages are not based on regular face-to-face interactions. There is no case of joint action in product development and no close supervision of production processes. Thus, these linkages are not effective in upgrading PTC silk-weaving establishments, as compared to the linkages taken place under JT's subcontracting arrangements.

Recently, PTC silk-weaving establishments have faced a cut-throat competition, because more producers have entered the market and those new entrants tend to compete in the same product lines instead of introducing new products to the markets. As the degree of competition has increased, the relationship between PTC producers has become hostile.

Consequently, problems that they collectively encounter (e.g., increasing prices of raw materials and low price of products) cannot be solved by the means of joint action. Despite some efforts to bring about the collective action to solve their business problems (e.g., the establishment of PTC Silk Association), hostile relations and antagonistic views among PTC silk fabric producers prevent collective action from succeeding.

The finding here has some point relevant to the previous finding on the negative effects of *same-sector* agglomeration at 3- and 4-digit level. Since PTC silk-weaving industry consists of establishments producing similar products (i.e. silk fabrics), this cluster is characterized by the spatial agglomeration of a narrow-range production activity. From the case study, it is likely that the spatial agglomeration of establishments operating in a narrowly defined industry (i.e. silk weaving) results in intense competition and does not allow for collective action to take place. On the other hand, when some PTC producers still produced for JT, their core activity (weaving) was suitably linked to JT's downstream activities such as printing, clothing, and garment making. This linkage allowed for a close vertical cooperation between the buyer and subcontractors to take place. The main production activities of the buyer and the main production activities of the subcontractors tend to be complementary rather than competitive. Perhaps, the reason why the agglomeration of broad-range production activities (at 2-digit industrial level) is positive for productivity, whereas the agglomeration of narrow-range production activities (at 3- and 4-digit industrial levels) is negative for productivity is related to the linkages between establishments through production complementarity. Specifically, the spatial agglomeration of establishments undertaking broad-range and loosely related activities increase the chances that establishments will develop production linkages with each other through complementary production processes. On the other hand, the spatial agglomeration of narrow-range activities leads to intense competition, as production activities undertaken by establishments are competitive rather than complementary.

The findings from the case study of PTC's silk-waving industry inform the existing literature on industrial clustering as follows. First, the main finding from the case study supports the collective efficiency framework (Schmitz and Nadvi 19999) which proposes that the co-location of establishments *per se* is not sufficient for establishments in the cluster to maintain their competitiveness and enjoy sustainable growth. In order to stay robust and enjoy sustainable growth, establishments in the cluster need to have collaborative efforts and joint actions (Knorringa 1999; Nadvi 1999; Rabellotti 1999; Schmitz and Nadvi 1999). In our case, under subcontracting arrangements between JT and its subcontractors, cooperation and joint actions between the buyer (JT) and subcontractors took place at every stage of production (from product trial run to products examination). As a result, subcontractors were upgraded and enjoyed a long-term growth. With the absence of collaborative efforts and joint actions, PTC silk-weaving establishments were not able to overcome risks and challenges that they collectively faced such as increased prices of raw materials and low prices of silk fabrics.

Second, as indicated by the collective efficiency frameworks, collaborative efforts and joint action can take place *horizontally* as well as *vertically* (Nadvi 1999). Horizontal joint action is the collaboration among establishments operating in the same product line, while vertical joint action refers to the collaboration between establishments at different stages of production, i.e., buyer-subcontractor relationships (Nadvi 1999). In our case, it is found that vertical cooperation between buyer and subcontractors is relevant for the upgrading and developments of subcontractors. This is consistent with the previous studies by Knorringa (1999) and Nadvi (1999) which show that vertical cooperation is a key mechanism that helps establishments in industrial clusters to overcome risks and challenges and to enjoy long-term growth.

Finally, as observed from our case study, the buyer (JT) played an important role in the upgrading of subcontractors. This finding supports the arguments made by some scholars who investigated the role of buyers in helping small producers in industrial clusters to upgrade their technological capabilities (Schmitz and Knorringa 2000; Humphrey and Schmitz 2002). These scholars argue that small producers can upgrade their technological capabilities by establishing subcontracting relationships with large and technologically advanced buyers. This is because in order to ensure that products will meet their requirements; buyers have to help enhance the production capabilities of their subcontractors (Schmitz and Knorringa 2000; Humphrey and Schmitz 2002). This is relevant, especially in the case of rural-based industry. As in our case, before 1967, rural silk-fabric producers in PTC relied on traditional production methods; and there were limited alternatives for them to upgrade their technological capabilities. However, by establishing subcontracting relationships with the technologically advanced buyer (JT), they could upgrade their products and production processes. This was possible with the assistance of JT who had to ensure that its subcontractors would meet their requirements. As a result of technological transfers from JT to its subcontractors, the subcontractors could develop from a small cottage industry into modern establishments employing more advanced methods.

7.3 Policy implication

From the findings, policy implication can be also drawn. As the effects of industrial clustering on manufacturing establishment's productivity vary in accordance with sectoral scope of agglomeration, industrial promotion schemes aiming to enhance productivity of establishments in the industrial cluster should be aware of these variations. A one-size-fits-all scheme does not seem to be an appropriate strategy. For example, this analysis has revealed that promoting a clustering of broad-range and complementary activities at provincial or subregional level can have positive effects on the labor productivity of manufacturing establishments. Therefore, industrial promotion scheme should focus on facilitating the spatial agglomeration of broad-range and complementary activities either at the provincial or subregional level.

7.4 Future research issues

The current research took the case of Thai manufacturing industries to examine the causes and effects of spatial clustering of manufacturing establishments as well as the mechanisms through which clustering may contribute to the improvement of establishments' economic performance. However, as industrial clustering is a broad concept, there are still several issues which have not been covered in this study. Based on the current research, I have found that there are some issues that can be stated as future research issues as follows.

First, it is argued by Krugman (1991a, 1991b) that there are large differences in location and spatial distribution between agricultural activities whose production is subject to constant returns to scale and intensive use of immobile land and manufacturing whose production is determined by increasing return to scale. However, it may be interesting to examine the formation of industrial clusters which rely largely on agricultural activities (such as food product cluster). Specifically, the future research can investigate how the industrial cluster is developed from agricultural sector.

Second, due to the limitation in terms of data availability, the current study still defined the spatial scopes of agglomeration based mainly on administrative units (province and subregion). However, the boundary of industrial agglomeration may not be the same as the boundary of the administrative unit. In this case, this study neither capture spatial lag effects nor identify the effects of clustering that may take place at continuous spatial scopes. The future research may take this issue into consideration in order to examine spatial lags effects of clustering. Of course, this can be done only when very fine geographical data on the location of establishments are available.

Finally, the effects of industrial clustering are not constant over time. For instance, the effects of industrial clustering today may change in both magnitude and direction (positive or negative) in the next five years (see Rosenthal and Strange 2004). However, due to the lack of longitudinal data at the establishment level, this study could only examine the effect of clustering on establishments' productivity at a single point in time. Thus, it did not capture the dynamic effects of clustering. With the longitudinal data at the establishment level, the future research can identify the dynamic effects of industrial clustering on establishments' productivity.

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Appendices

Appendix 1.1: The number of manufacturing establishments by size of establishments (Number of employees), Industrial Census 1997

# Employees (persons)	# Establishments	Percent
1 – 4	1,475	4.54
5 – 9	3,660	11.27
10 – 19	11,701	36.02
20 – 49	7,389	22.74
50 – 99	3,264	10.05
100 – 199	2,194	6.75
200 – 499	1,742	5.36
500 – 999	627	1.93
1,000 or more	437	1.35
Total	32,489	100.00

Source: NSO

Appendix 1.2: The number of manufacturing establishments by size of establishments (Number of employees), Industrial Census 2007

# Employees (persons)	# Establishments	Percent
1	9,603	12.99
2 - 3	14,170	19.17
4 -5	6,740	9.12
6 - 10	8,793	11.89
11 - 15	8,332	11.27
16 - 20	4,770	6.45
21 - 25	3,326	4.50
26 - 30	2,494	3.37
31 - 50	5,150	6.97
51 - 100	4,058	5.49
101 - 200	2,919	3.95
201 - 500	2,222	3.01
501 - 1000	817	1.11
1000 or more	537	0.73
Total	73,931	100.00

Source: NSO

Appendix 3.1: List of Provinces and Region in Thailand

Region		Province	Abbreviation	Number of Establishments	
				1996	2006
	1	Bangkok	BKK	14079	9818
Inner Ring	2	Samut Prakan	SPRA	2269	4063
	3	Nonthaburi	NOTB	670	997
	4	Pathum Thani	PATHU	925	1832
	5	Nakhon Pathom	NKPT	1277	2030
	6	Samut Sakon	SSAK	1483	2814
Outer Ring	7	Ayutthaya	PNSA	513	1208
	8	Ang Thong	ANG	48	379
	9	Saraburi	SARA	333	609
	10	Nakhon Nayok	NKNY	58	380
	11	Chachoengsao	CHCS	396	918
	12	Chon Buri	CHON	896	1632
	13	Suphan Buri	SUPAN	237	776
	14	Ratchaburi	RACBR	485	1117
	15	Kanchanaburi	KANC	215	858
	16	Samut Songkram	SSOK	115	308
	17	Rayong	RAYO	405	846
Centre	18	Lop Buri	LOP	104	799
	19	Sing Buri	SING	103	516
	20	Chai Nat	CHNA	68	546
	21	Chanthaburi	CHAN	129	407
	22	Trat	TRAT	43	157
	23	Prachin Buri	PRACH	130	528
	24	Phetcha Buri	PCBR	105	535
	25	Prachuapkhiri Khan	PCKK	107	334
	26	Nakhon Sawan	NKSW	199	948
	27	Uthai Thani	UTHAI	39	339
	28	Kamphaeng Phet	KAMP	87	645
	29	Tak	TAK	125	552
	30	Sukhothai	SUKHO	129	575
	31	Phisanulok	PHISA	132	817
	32	Phichit	PHCH	126	465
	33	Phetchabun	PHCB	60	696
North	34	Chiang Mai	CHMAI	582	1725
	35	Lamphun	LUMPH	232	1003
	36	Lampang	LUMP	293	1170
	37	Uttaradit	UTTAR	61	519
	38	Phrae	PHRA	112	990
	39	Nan	NAN	50	747
	40	Phayao	PHYAO	87	983
	41	Chiang Rai	CHRAI	276	1557
	42	Mae Hong Son	MHS	12	223

Region		Province	Abbreviation	Number of Establishments	
				1996	2006
Northeast	43	Nakhon Ratchasima	NKRS	410	1065
	44	Buri Ram	BURR	62	748
	45	Surin	SURIN	86	1172
	46	Si Sa Ket	SSK	87	1113
	47	Ubon Ratchathani	UBON	224	1271
	48	Yasothon	YASO	40	639
	49	Chaiyaphum	CHYP	88	746
	50	Amnat Charoen	AMN	46	681
	51	Nong Bua Lam Phu	NBLP	14	690
	52	Khon Kaen	KHON	484	1808
	53	Udon Thani	UDON	147	717
	54	Loei	LOEI	48	574
	55	Nong Khai	NOKH	205	549
	56	Maha Sarakham	MAHA	36	1211
	57	Roi Et	ROIET	157	1635
	58	Kalasin	KALA	104	974
	59	Sakon Nakhon	SAKON	49	483
	60	Nakhon Phanom	NKPN	44	656
	61	Mukdahan	MUK	58	523
	62	Sra Kaew	SRA	71	358
South	63	Nakhon Si Thammarat	NKST	315	963
	63	Krabi	KRAB	71	346
	64	Phangnga	PHANG	88	351
	65	Phuket	PHUK	194	367
	66	Surat Thani	SURAT	203	655
	67	Ranong	RANO	109	280
	68	Chumphon	CHUM	113	425
	69	Songkhla	SONG	435	1155
	70	Satun	SATU	58	381
	71	Trang	TRANG	224	851
	72	Phatthalung	PHAT	109	785
	73	Pattani	PATTA	131	594
	74	Yala	YALA	102	256
	75	Narathiwat	NARAT	82	548

Appendix 3.2: List of 2- and 3-digit industries

2-digit Industrial Classification		3-digit Industrial Classification	
ISIC		**ISIC**	
15	Food products and beverages	151	Production, processing and preservation of meat, fish, fruit, vegetables, oils and fats
		152	Dairy products
		153	Grain mill products and starch products, and prepared animal feeds
		154	Other food products
		155	Beverages
16	Tobacco products	160	Tobacco products
17	Textiles	171	Spinning, weaving and finishing of textiles
		172	Other textiles
		173	Knitted and crocheted fabrics and articles
18	Wearing apparel; dressing and dyeing of fur	181	Wearing apparel, except fur apparel
		182	Dressing and dyeing of fur; manufacture of articles of fur
19	Leather and leather products	191	Tanning and dressing of leather; luggage, handbags, saddler and harness
		192	Footwear
20	Wood and products of wood and cork	201	Sawmilling and plating of wood
		202	Products of wood, cork, straw and plaiting materials
21	Paper and paper products	210	Paper and paper products
22	Publishing, printing and reproduction of recorded media	221	Printing
		222	Service activities related to printing
		223	Reproduction of recorded media
23	Coke and refined petroleum products	231	Coke oven products
		232	Refined petroleum products
24	Chemicals and chemical products	241	Basic chemicals
		242	Other chemical products
		243	Man-made fibers
25	Rubber and plastics products	251	Rubber products
		252	Plastic products
26	Non-metallic and mineral products	261	Glass and glass products
		269	Non-metallic and mineral products, not elsewhere classified (n.e.c.)
27	Basic metals	271	Basic iron and steel
		272	Basic precious and non-ferrous metals
		273	Casting of metals

2-digit Industrial Classification		3-digit Industrial Classification	
ISIC		**ISIC**	
28	Fabricated metal products, except machinery and equipments	281	Structural metal products, tanks, reservoirs and steam generators
		289	Other fabricated metal products; service activities to producers of fabricated metal products
29	Machinery and equipment, n.e.c.	291	General purpose machinery
		292	Special purpose machinery
		293	Domestic appliances n.e.c.
30	Office, accounting and computing machineries	300	Office, accounting and computing machineries
31	Electrical machineries and apparatus	311	Electric motors, generators and transformers
		312	Electricity distribution and control apparatus
		313	Insulated wire and cable
		314	Accumulators, primary cells and batteries
		315	Electric lamp
		319	Other electrical equipment n.e.c.
32	Radio, television and communication equipments and apparatus	321	Electronic valves and tubes and other electronic components
		322	Television and radio transmitters and apparatus for line telephony and line telegraphy
		323	Television and radio receivers and associated consumer goods
33	Medical, precision and optical instruments, watches and clocks	331	Medical appliances and instruments for measuring, checking, testing, navigating
		332	Optical instruments and photographic equipment
		333	Watches and clocks
34	Motor vehicles, trailers and semi-trailers	341	Motor vehicles
		342	Bodies (coachwork) for motor vehicles; manufacture of trailers and semi- trailers
		343	Parts and accessories for motor vehicles and their engines
35	Other transport equipment	351	Building and repairing of ships and boats
		353	Aircraft and spacecraft
		359	Transport equipment n.e.c.
36	Furniture	361	Furniture
		369	Manufacturing of furniture, n.e.c.
37	Recycling	371	Recycling of metal waste and scrap
		372	Recycling of non-metal waste and scrap

Appendix 3.3: Ranking of average Gini coefficient for 3-digit industries (1996-2006)

		3-digit industries			
ISIC	**Gini (Ave.)**	**Rank**	**ISIC**	**Gini (Ave.)**	**Rank**
ISIC151	0.487	56	ISIC273	0.855	27
ISIC152	0.560	53	ISIC281	0.587	52
ISIC153	0.432	57	ISIC289	0.718	45
ISIC154	0.417	58	ISIC291	0.854	28
ISIC155	0.525	55	ISIC292	0.719	44
ISIC160	0.885	14	ISIC293	0.897	12
ISIC171	0.727	43	ISIC300	0.901	11
ISIC172	0.658	48	ISIC311	0.833	35
ISIC173	0.846	31	ISIC312	0.919	7
ISIC181	0.689	47	ISIC313	0.933	5
ISIC182	0.917	9	ISIC314	0.940	4
ISIC191	0.838	33	ISIC315	0.929	6
ISIC192	0.864	25	ISIC319	0.883	16
ISIC201	0.639	49	ISIC321	0.883	15
ISIC202	0.536	54	ISIC322	0.880	17
ISIC210	0.873	20	ISIC323	0.869	23
ISIC221	0.818	37	ISIC331	0.827	36
ISIC222	0.775	42	ISIC332	0.917	8
ISIC223	0.945	3	ISIC333	0.949	2
ISIC231	0.887	13	ISIC341	0.858	26
ISIC232	0.867	24	ISIC342	0.834	34
ISIC241	0.712	46	ISIC343	0.877	19
ISIC242	0.784	40	ISIC351	0.800	38
ISIC243	0.911	10	ISIC353	0.957	1
ISIC251	0.796	39	ISIC359	0.846	30
ISIC252	0.872	21	ISIC361	0.635	50
ISIC261	0.775	41	ISIC369	0.627	51
ISIC269	0.415	59	ISIC371	0.876	22
ISIC271	0.877	18	ISIC372	0.849	29
ISIC272	0.843	32			

Source: Author’s calculation

Appendix 3.4: Average Gini coefficient by industrial category, 1996-2006 (3-digit)

Industry category	**Average Gini 1996-2006**
Resource-based	0.650
Labor-intensive	0.778
MCP	0.808
Machinery	0.877
Grand mean	0.790

Note: MCP = metal, chemicals, and paper industries
Source: Author's calculation

Appendix 3.5: Changes in Gini coefficients (3-digit industries)

	Gini coefficient				Gini coefficient		
	1996	**2006**	**Change (%)**		**1996**	**2006**	**Change (%)**
ISIC151	0.596	0.379	-36.4	ISIC273	0.907	0.802	-11.6
ISIC152	0.743	0.377	-49.3	ISIC281	0.848	0.326	-61.6
ISIC153	0.534	0.329	-38.4	ISIC291	0.916	0.792	-13.5
ISIC154	0.579	0.254	-56.1	ISIC292	0.868	0.57	-34.3
ISIC155	0.649	0.401	-38.2	ISIC293	0.936	0.858	-8.3
ISIC160	0.936	0.833	-11.1	ISIC300	0.918	0.885	-3.5
ISIC171	0.851	0.604	-29.1	ISIC311	0.921	0.745	-19.2
ISIC172	0.883	0.432	-51.1	ISIC312	0.929	0.909	-2.2
ISIC173	0.937	0.755	-19.4	ISIC313	0.936	0.93	-0.7
ISIC181	0.901	0.476	-47.1	ISIC314	0.943	0.936	-0.8
ISIC182	0.913	0.92	0.8	ISIC315	0.932	0.926	-0.6
ISIC192	0.935	0.793	-15.2	ISIC319	0.886	0.88	-0.7
ISIC201	0.696	0.581	-16.5	ISIC321	0.893	0.873	-2.3
ISIC202	0.722	0.35	-51.6	ISIC322	0.915	0.846	-7.5
ISIC210	0.919	0.827	-10	ISIC323	0.915	0.824	-9.9
ISIC221	0.92	0.715	-22.3	ISIC331	0.928	0.725	-21.8
ISIC222	0.924	0.626	-32.2	ISIC332	0.938	0.896	-4.5
ISIC223	0.951	0.939	-1.3	ISIC333	0.943	0.954	1.2
ISIC231	0.914	0.861	-5.8	ISIC341	0.857	0.858	0.1
ISIC232	0.887	0.847	-4.6	ISIC342	0.86	0.809	-5.9
ISIC241	0.817	0.608	-25.6	ISIC343	0.9	0.854	-5
ISIC242	0.907	0.66	-27.3	ISIC351	0.865	0.735	-15.1
ISIC243	0.954	0.868	-9	ISIC353	0.97	0.943	-2.8
ISIC251	0.815	0.778	-4.5	ISIC359	0.933	0.759	-18.6
ISIC252	0.904	0.839	-7.2	ISIC361	0.796	0.473	-40.6
ISIC261	0.902	0.648	-28.1	ISIC369	0.82	0.434	-47
ISIC269	0.47	0.36	-23.5	ISIC371	0.952	0.801	-15.9
ISIC271	0.917	0.837	-8.7	ISIC372	0.932	0.766	-17.9
ISIC272	0.917	0.769	-16.1				

Source: Author

Appendix 3.6: Number of 2-digit manufacturing industrial establishments, 1996 and 2006

ISIC	**1996**	**2006**	**Change**
ISIC15	4666	16416	11750
ISIC16	253	162	-91
ISIC17	1950	7839	5889
ISIC18	2743	5494	2751
ISIC19	1159	1561	402
ISIC20	1221	5036	3815
ISIC21	803	1176	373
ISIC22	1650	2396	746
ISIC23	60	90	30
ISIC24	1244	2732	1488
ISIC25	2382	3104	722
ISIC26	3106	5344	2238
ISIC27	589	1119	530
ISIC28	3455	8239	4784
ISIC29	1407	2537	1130
ISIC30	82	70	-12
ISIC31	605	791	186
ISIC32	315	635	320
ISIC33	177	290	113
ISIC34	1501	1007	-494
ISIC35	281	564	283
ISIC36	2797	7171	4374
ISIC37	43	158	115
Total	**32489**	**73931**	**41442**

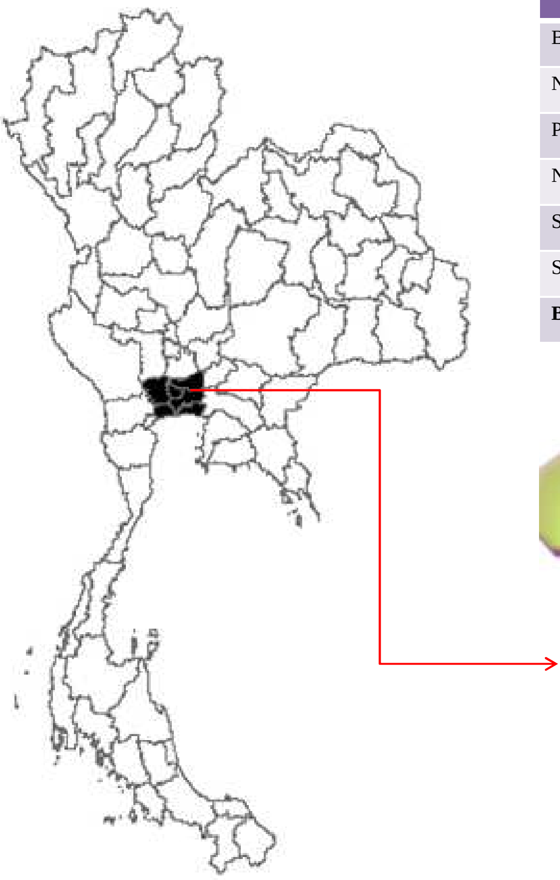
Source: NSO

Appendix 3.7: Number of 3-digit manufacturing industrial establishments, 1996 and 2006

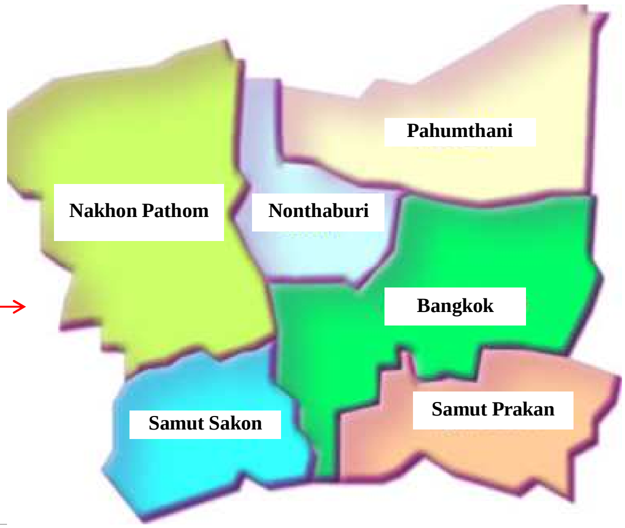
	1996	2006	Change		1996	2006	Change
ISIC151	1347	4527	3180	ISIC273	253	423	170
ISIC152	219	488	269	ISIC281	1147	3179	2032
ISIC153	1328	2985	1657	ISIC289	2308	5060	2752
ISIC154	1339	6634	5295	ISIC291	583	826	243
ISIC155	433	1782	1349	ISIC292	656	1534	878
ISIC160	253	162	-91	ISIC293	168	177	9
ISIC171	1169	4784	3615	ISIC300	82	70	-12
ISIC172	641	2714	2073	ISIC311	96	274	178
ISIC173	140	341	201	ISIC312	178	194	16
ISIC181	2724	5475	2751	ISIC313	33	79	46
ISIC182	19	19	0	ISIC314	20	37	17
ISIC191	427	741	314	ISIC315	96	112	16
ISIC192	732	820	88	ISIC319	182	95	-87
ISIC201	422	692	270	ISIC321	150	443	293
ISIC202	799	4344	3545	ISIC322	45	52	7
ISIC210	803	1176	373	ISIC323	120	140	20
ISIC221	330	541	211	ISIC331	104	215	111
ISIC222	1304	1838	534	ISIC332	41	46	5
ISIC223	16	17	1	ISIC333	32	29	-3
ISIC231	11	14	3	ISIC341	238	67	-171
ISIC232	48	76	28	ISIC342	775	147	-628
ISIC241	432	1119	687	ISIC343	488	793	305
ISIC242	787	1583	796	ISIC351	94	245	151
ISIC243	25	30	5	ISIC353	4	6	2
ISIC251	665	811	146	ISIC359	180	313	133
ISIC252	1717	2293	576	ISIC361	1383	2844	1461
ISIC261	124	253	129	ISIC369	1414	4327	2913
ISIC269	2982	5091	2109	ISIC371	11	43	32
ISIC271	228	422	194	ISIC372	32	115	83
ISIC272	108	274	166				
				Total	**32,489**	**73,931**	**41,442**

Source: NSO

Appendix 3.8: Location, area, population and population density of BMR



	Area (Km^2)	Population	Pop. Dens.
Bangkok	1,568.7	5,716,248	3,643.9
Nonthaburi	2,168.3	1,024,191	472.3
Pathum Thani	622.3	815,402	1,310.3
Nakhon Pathom	1,525.8	830,970	544.6
Samut Prakan	1,004.1	1,126,940	1,122.3
Samut Sakon	872.3	469,934	538.7
BMR	7,761.5	9,983,685	1,286.3



Note: Number of (registered) population and population density are at the end of 2007

Source: Author’s complication from NSO’s provincial statistics reports 2007

Appendix 4.1: Descriptive statistics of key variables (BMR location)

a. Motor vehicles (ISIC34)

	Min	Max	Mean	SD
Y_i	0.00	1.00	0.54	0.50
$SIZE_{ir}$	0.69	7.97	3.85	1.62
$INPUT_{ir}$	0.00	1.00	0.75	0.27
FOR_{ir}	0.00	1.00	0.16	0.36
EXP_{ir}	0.00	1.00	0.28	0.45
$INDEP_{ir}$	0.00	1.00	0.85	0.36
$SKILL_{ir}$	0.00	1.00	0.58	0.31
RES_r	7.25	11.8	9.97	0.70
LAB_r	11.8	15.1	13.5	0.84
$SKWF_r$	0.03	0.36	0.15	0.06
$AG96_r$	0.00	6.57	4.07	1.51
IE_r	0.00	1.00	0.76	0.43
N = 1,007				

Source: Author's calculation

b. Foods and beverages (ISIC15)

	Min	Max	Mean	SD
Y_i	0.00	1.00	0.14	0.34
$SIZE_{ir}$	0.69	8.78	2.19	1.29
$INPUT_{ir}$	0.00	1.00	0.75	0.24
FOR_{ir}	0.00	1.00	0.00	0.05
EXP_{ir}	0.00	1.00	0.05	0.22
$INDEP_{ir}$	0.00	1.00	0.95	0.23
$SKILL_{ir}$	0.00	1.00	0.32	0.37
RES_r	7.25	11.8	9.22	0.75
LAB_r	11.4	15.1	13.0	0.68
$SKWF_r$	0.03	0.36	0.11	0.05
$AG96_r$	0.69	6.51	3.95	1.03
IE_r	0.00	1.00	0.23	0.42
N = 16,416				

Source: Author's calculation

c. Textiles (ISIC17)

	Min	Max	Mean	SD
Y_i	0.00	1.00	0.18	0.39
$SIZE_{ir}$	0.69	7.80	2.41	1.39
$INPUT_{ir}$	0.00	1.00	0.77	0.23
FOR_{ir}	0.00	1.00	0.01	0.07
EXP_{ir}	0.00	1.00	0.04	0.20
$INDEP_{ir}$	0.00	1.00	0.97	0.17
$SKILL_{ir}$	0.00	1.00	0.35	0.42
RES_r	7.25	11.8	9.15	0.72
LAB_r	11.4	15.1	13.2	0.6
$SKWF_r$	0.03	0.36	0.10	0.05
$AG96_r$	0.00	6.71	2.46	1.83
IE_r	0.00	1.00	0.21	0.41
$N = 7{,}839$				

Source: Author's calculation

Appendix 4.2: Correlation matrix of key variables (BMR location)

a. Motor vehicles (ISIC34)

	Y_i	$TCOST_{ir}$	$SIZE_{ir}$	$INPUT_{ir}$	FOR_{ir}	EXP_{ir}	$INDEP_{ir}$	$SKILL_{ir}$	RES_r	LAB_r	$SKWF_r$	$AG96_r$	IE_r
Y_i	1												
$TCOST_{ir}$	.05	1											
$SIZE_{ir}$	.03	.08	1										
$INPUT_{ir}$	-.14 [a]	.08	.05	1									
FOR_{ir}	-.32 [a]	.01	.37 [a]	.06	1								
EXP_{ir}	-.23 [a]	-.01	.51 [a]	.07 [b]	.54 [a]	1							
$INDEP_{ir}$	-.03	.16 [a]	-.34 [a]	.03	-.02	-.17 [a]	1						
$SKILL_{ir}$	.01	.20 [a]	.19 [a]	.02	.05	.06	-.07 [b]	1					
RES_r	.03	.20 [a]	.19 [a]	.01	.14 [a]	.20 [a]	.04	.08 [b]	1				
LAB_r	.45 [a]	.20 [a]	-.02	-.09 [a]	-.16 [a]	-.08 [a]	.02	.01	.48 [a]	1			
$SKWF_r$	.20 [a]	-.15 [b]	.27 [a]	.03	.19 [a]	.19 [a]	-.07 [b]	-.01	.11 [a]	-.16 [a]	1		
$AG96_r$	.65 [a]	.21 [a]	.17 [a]	-.11 [a]	-.11 [a]	-.02	-.04	.09 [a]	.49 [a]	.82 [a]	.03	1	
IE_r	.09 [a]	.13 [b]	.35 [a]	.03	.16 [a]	.21 [a]	-.06	.10 [a]	.53 [a]	.25 [a]	.07 [b]	.45 [a]	1
N = 1,007													

Note: [a] and [b] denote statistical significance at 1% and 5% levels, respectively.
Source: Author's calculation

b. Foods and beverages (ISIC15)

	Y_i	$TCOST_{ir}$	$SIZE_{ir}$	$INPUT_{ir}$	FOR_{ir}	EXP_{ir}	$INDEP_{ir}$	$SKILL_{ir}$	RES_r	LAB_r	$SKWF_r$	$AG96_r$	IE_r
Y_i	1												
$TCOST_{ir}$	-.02	1											
$SIZE_{ir}$	.33[a]	.01	1										
$INPUT_{ir}$	.02[b]	.04[a]	.02[b]	1									
FOR_{ir}	.06[a]	-.03	.13[a]	-.01	1								
EXP_{ir}	.20[a]	.01	.51[a]	.01	.13[a]	1							
$INDEP_{ir}$	-.15[a]	.01	-.45[a]	-.01	-.11[a]	-.38[a]	1						
$SKILL_{ir}$	.13[a]	-.01	.37[a]	.02[b]	.02[a]	.11[a]	-.11[a]	1					
RES_r	.31[a]	.01	.21[a]	.01	.03[a]	.14[a]	-.12[a]	.11[a]	1				
LAB_r	.32[a]	.01	.11[a]	-.02[b]	.02[a]	.06[a]	-.07[a]	.08[a]	.59[a]	1			
$SKWF_r$	.33[a]	-.03[b]	.14[a]	.02[b]	.05[a]	.12[a]	-.10[a]	.10[a]	.24[a]	-.03[a]	1		
$AG96_r$	.59[a]	.01	.30[a]	.02[b]	.04[a]	.18[a]	-.14[a]	.16[a]	.67[a]	.55[a]	.22[a]	1	
IE_r	.41[a]	.02	.27[a]	.01	.04[a]	.18[a]	-.12[a]	.12[a]	.42[a]	.13[a]	.23[a]	.52[a]	1
N = 16,416													

Note: [a] and [b] denote statistical significance at 1% and 5% levels, respectively.
Source: Author's calculation

c. Textiles (ISIC17)

	Y_i	$TCOST_{ir}$	$SIZE_{ir}$	$INPUT_{ir}$	FOR_{ir}	EXP_{ir}	$INDEP_{ir}$	$SKILL_{ir}$	RES_r	LAB_r	$SKWF_r$	$AG96_r$	IE_r
Y_i	1												
$TCOST_{ir}$	-.04[a]	1											
$SIZE_{ir}$	.42[a]	.02	1										
$INPUT_{ir}$	-.04[a]	.08	-.01	1									
FOR_{ir}	.08[a]	.03[a]	.14[a]	.01	1								
EXP_{ir}	.24[a]	.01	.41[a]	-.01	.26[a]	1							
$INDEP_{ir}$	-.19[a]	.02	-.33[a]	.01	-.15[a]	-.41[a]	1						
$SKILL_{ir}$	.24[a]	.04	.41[a]	-.01	.05[a]	.12[a]	-.11[a]	1					
RES_r	.56[a]	-.06[b]	.27[a]	-.02[b]	.07[a]	.20[a]	-.15[a]	.19[a]	1				
LAB_r	.40[a]	.00	.18[a]	.00	.03[b]	.08[a]	-.06[a]	.19[a]	.66[a]	1			
$SKWF_r$	.48[a]	.02	.17[a]	-.02[b]	.10[a]	.20[a]	-.12[a]	.09	.35[a]	.03[a]	1		
$AG96_r$	.83[a]	-.04[b]	.40[a]	-.02	.08[a]	.23[a]	-.17[a]	.30[a]	.71[a]	.63[a]	.35[a]	1	
IE_r	.68[a]	-.04[a]	.33[a]	-.02	.08[a]	.24[a]	-.17[a]	.17[a]	.60[a]	.29[a]	.39[a]	.69[a]	1
N = 7,839													

Note: [a] and [b] denote statistical significance at 1% and 5% levels, respectively.
Source: Author's calculation

Appendix 4.3: Binary logistic regression results for the motor vehicles industry (BMR + Chon Buri, Chachoengsao, Rayong, and Ayutthaya)

	(1)		(2)	
	B	Exp(B)	B	Exp(B)
Constant	-7.04(0.84)[a]	0.00	-17.3(2.18)[a]	0.00
$SIZE_{ir}$	0.67(0.11)[a]	1.96	-	-
$INPUT_{ir}$	-0.75(0.48)	0.47	-	-
FOR_{ir}	1.11(0.48)[b]	3.04	-	-
EXP_{ir}	0.12(0.40)	1.13	-	-
$INDEP_{ir}$	0.24(0.38)	1.27	-	-
$SKILL_{ir}$	1.56(0.46)[a]	4.76	-	-
RES_r	-	-	-0.70(0.28)[a]	0.495
LAB_r	-	-	1.40(0.27)[a]	4.035
$SKWF_r$	-	-	40.10(3.47)[a]	2.61E+17
$AG96_r$	2.03(0.17)[a]	7.63	-	-
IE_r	-	-	3.19(0.30)[a]	24.21
-2Log-Likelihood	453[a]		488[a]	
R^2*(Cox & Snell)*	0.43		0.41	
# Obs.	1,007		1,007	

Notes: (1) BMR, Chon Buri, Chachoengsao, Rayong, and Ayutthaya = 1; other provinces = 0; (2) [a] and [b] denote statistical significance at 1% and 5% levels, respectively.
Source: Author's estimation

Appendix 5.1: List of Subregion

Subregion	**Province**
Upper Northeast-1	Nong Khai
	Loei
	Udon Thani
	Nong Bua Lam Phu
Upper Northeast-2	Mukdahan
	Nakhon Phanom
	Sakon Nakhon
Central Northeast	Khon Kaen
	Maha Sarakham
	Kalasin
	Roi Et
Lower Northeast-1	Nakhon Ratchasima
	Chaiyaphum
	Buri Ram
	Surin
Lower Northeast-2	Ubon Ratchathani
	Amnat Charoen
	Si Sa Ket
	Yasothon
Upper North-1	Chiang Mai
	Lampang
	Lamphun
	Mae Hong Son
Upper North-2	Chiang Rai
	Phayao
	Nan
	Phrae
Lower North-1	Phetchabun
	Phisanulok
	Tak
	Sukhothai
	Uttaradit
Lower North-2	Nakhon Sawan
	Kamphaeng Phet
	Uthai Thani
	Phichit
West-Coast South	Phuket
	Phangnga
	Krabi
	Trang
	Ranong

Subregion	Province
East Coast South	Surat Thani
	Chumphon
	Nakhon Si Thammarat
	Phatthalung
Southern Border	Satun
	Yala
	Songkhla
	Pattani
	Narathiwat
East-1	Chachoengsao
	Prachin Buri
	Nakhon Nayok
	Sra Kaew
East-2	Chanthaburi
	Chon Buri
	Trat
	Rayong
West-1	Kanchanaburi
	Ratchaburi
	Suphan Buri
West-2	Samut Songkram
	Prachuapkhiri Khan
	Phetchaburi
Centre-1	Phra Nakhon Si Ayutthaya
	Saraburi
Centre-2	Ang Thong
	Lop Buri
	Sing Buri
	Chai Nat
BMR	Bangkok
	Nakhon Pathom
	Nonthaburi
	Pathum Thani
	Samut Prakan
	Samut Sakon

Appendix 5.2: 2SLS regressions results for provincial density subsamples

	(1) Highest-Density Group						(2) High-Density Group					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	2.60(0.14)[a]	2.51(.20)[a]	2.59(.19)[a]	2.61(.13)[a]	2.97(.21)[a]	3.15(.25)[a]	1.18(.22)[a]	1.22(.35)[a]	1.24(.34)[a]	.28(.26)[a]	1.05(.34)[a]	1.08(.32)[a]
lnK_{ijr}	.78(.01)[a]	.77(.01)[a]	.77(.01)[a]	.77(.01)[a]	.78(.01)[a]	.77(.01)[a]	.76(.01)[a]	.76(.01)[a]	.76(.01)[a]	.76(.01)[a]	.76(.01)[a]	.76(.01)[a]
$ln\ L_{ijr}$	-1.03(.01)[a]	-1.03(.01)[a]	-1.03(.01)[a]	-1.03(.01)[a]	-1.03(.01)[a]	-1.03(.01)[a]	-1.07(.01)[a]	-1.06(.01)[a]	-1.06(.01)[a]	-1.07(.01)[a]	-1.06(.01)[a]	-1.06(.01)[a]
$lnLE_{jr}\_1$	-.12(.03)[a]						.12(.04)[a]					
$lnUE_{r}\_1$	-.21(.06)[a]						.04(.10)					
$lnLE_{jr}\_2$		-.24(.01)[a]						-.10(.02)[a]				
$lnUE_{r}\_2$		-.02(.07)						.26(.12)[b]				
$lnLE_{jr}\_3$			-.21(.01)[a]						-.06(.02)[a]			
$lnUE_{r}\_3$			-.10(.05)[b]						.16(.08)[b]			
$lnLE_{jr}\_4$				.09(.02)[a]						.18(.02)[a]		
$lnUE_{r}\_4$				-.59(.05)[a]						.30(.10)[a]		
$lnLE_{jr}\_5$					-.17(.02)[a]						-.06(.02)[a]	
$lnUE_{r}\_5$					-.13(.07)[c]						.30(.11)[a]	
$lnLE_{jr}\_6$						-.15(.01)[a]						-.03(.02)[c]
$lnUE_{r}\_6$						-.22(.07)[a]						.20(.08)[a]
$COMP_{jr}$	.33(.02)[a]	.41(.02)[a]	.37(.01)[a]	.21(.02)[a]	.32(.01)[a]	.30(.01)[a]	.37(.03)[a]	.50(.02)[a]	.48(.2)[a]	.35(.02)[a]	.49(.02)[a]	.47(.02)[a]
EXP_{ijr}	.08(.04)[c]	.07(.04)[c]	.07(.04)[c]	.08(.04)[b]	.05(.04)	.06(.04)	.15(.09)	.13(.09)	.13(.09)	.15(.09)	.12(.09)	.13(.09)
IMP_{ijr}	-.15(.04)[a]	-.20(.04)[a]	-.21(.04)[a]	-.10(.04)[a]	-.20(.04)[a]	-.20(.04)[a]	.21(.10)[b]	.15(.10)	.15(.10)	.23(.10)[b]	.15(.10)	.16(.10)[c]
FDI_{ijr}	-.06(.05)	-.12(.05)[a]	-.10(.05)[b]	.01(.05)	-.12(.05)[b]	-.10(.05)[c]	-.24(.15)	-.30(.15)[b]	-.27(.15)[c]	-.24(.15)	-.30(.15)[b]	-.27(.15)[c]
$SING_{ijr}$	-.05(.04)	-.01(.04)	.01(.04)	-.08(.04)[b]	-.03(.04)	-.02(.04)	-.11(.08)	-.10(.08)	-.08(.08)	-.11(.08)	-.10(.08)	-.08(.08)
RND_{ijr}	1.03(.06)[a]	1.02(.06)[a]	1.02(.06)[a]	1.04(.06)[a]	1.02(.06)[a]	1.02(.06)[a]	.95(.07)[a]	.94(.07)[a]	.94(.07)[a]	.95(.07)[a]	.94(.07)[a]	.94(.07)[a]
R^2	.707	.710	.710	.707	.708	.708	.714	.714	.714	.715	.714	.714
F-Stat.	6468[a]	6619[a]	6619[a]	6460[a]	6552[a]	6533[a]	3926[a]	3926[a]	6619[a]	3925[a]	3940[a]	3937[a]
Obs.(No.)	27,805	27,805	27,805	27,805	27,805	27,805	16,250	16,250	16,250	16,250	16,250	16,250

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

	(3) Low-Density Group						(4) Lowest-Density Group					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	1.47(.25)[a]	1.48(.33)[a]	1.17(.35)[a]	.08(.25)[a]	1.31(.41)[a]	1.19(.39)[a]	.61(.31)[b]	2.15(.49)[a]	2.39(.43)[a]	-.27(.30)	.96(.43)[b]	.87(.40)[b]
lnK_{ijr}	.81(.01)[a]	.82(.01)[a]	.82(.01)[a]	.80(.01)[a]	.82(.01)[a]	.82(.01)[a]	.75(.01)[a]	.77(.01)[a]	.77(.01)[a]	.75(.01)[a]	0.77(.01)[a]	.77(.01)[a]
$ln\ L_{ijr}$	-1.05(.01)[a]	-1.06(.01)[a]	-1.06(.01)[a]	-1.06(.01)[a]	-1.05(.01)[a]	-1.05(.01)[a]	-1.04(.01)[a]	-1.02(.01)[a]	-1.02(.01)[a]	-1.02(.01)[a]	-1.02(.01)[a]	-1.02(.01)[a]
$lnLE_{jr}\_1$	.19(.02)[a]						.45(.05)[a]					
$lnUE_{r}\_1$	-.34(.10)[a]						-.21(.15)					
$lnLE_{jr}\_2$		.17(.03)[a]						.03(.04)				
$lnUE_{r}\_2$		-.23(.10)[b]						-.31(.27)				
$lnLE_{jr}\_3$			.11(.03)[a]						.03(.04)			
$lnUE_{r}\_3$			.03(.08)						-.34(.12)[a]			
$lnLE_{jr}\_4$				.40(.02)[a]						.32(.03)[a]		
$lnUE_{r}\_4$				.17(.09)[c]						.20(.12)[c]		
$lnLE_{jr}\_5$					.13(.02)[a]						.04(.03)	
$lnUE_{r}\_5$					.20(.11)[c]						.10(.03)[a]	
$lnLE_{jr}\_6$						.05(.2)[a]						.05(.03)[b]
$lnUE_{r}\_6$						.01(.10)						.10(.09)
$COMP_{jr}$	.19(.02)[a]	.24(.02)[a]	.26(.02)[a]	.11(.02)[a]	.25(.02)[a]	.27(.02)[a]	.23(.04)[a]	.49(.03)[a]	.49(.03)[a]	.34(.03)[a]	.49(.03)[a]	.50(.03)[a]
EXP_{ijr}	-.03(.11)	-.05(.11)	-.06(.11)	-.02(.11)	-.05(.11)	-.06(.11)	.32(.13)[b]	.30(.13)[b]	.30(.13)[b]	.31(.13)[b]	.29(.13)[b]	.28(.13)[b]
IMP_{ijr}	.05(.12)	.06(.12)	.02(.12)	.13(.12)	.04(.12)	-.01(.12)	.03(.12)	-.04(.13)	-.03(.13)	.05(.13)	-.06(.13)	-.04(.13)
FDI_{ijr}	.48(.20)[b]	.48(.20)[b]	.42(.20)[b]	.54(.20)[a]	.45(.20)[b]	.40(.20)[b]	-.42(.20)[b]	-.52(.20)[a]	-.51(.20)[a]	-.41(.20)[b]	-.53(.20)[b]	-.52(.20)[a]
$SING_{ijr}$	-.19(.10)[b]	-.20(.10)[b]	-.19(.10)[c]	-.17(.10)[c]	-.17(.10)[c]	-.16(.10)	.19(.11)[c]	.22(.11)[b]	.21(.11)[b]	.25(.11)[b]	.23(.11)[b]	.22(.11)[b]
RND_{ijr}	.95(.07)[a]	.97(.07)[a]	.98(.07)[a]	.95(.07)[a]	.97(.07)[a]	.97(.07)[a]	.93(.09)[a]	.92(.09)[a]	.91(.09)[a]	.92(.09)[a]	.92(.09)[a]	.92(.09)[a]
R^2	.698	.698	.697	.705	.697	.696	.694	.691	.692	.696	.691	.691
F-Stat.	2628[a]	2617[a]	2607[a]	2705[a]	2610[a]	2601[a]	1893[a]	1874[a]	1873[a]	1903[a]	1875[a]	1875[a]
Obs.(No.)	12,074	12,074	12,074	12,074	12,074	12,074	8,898	8,898	8,898	8,898	8,898	8,898

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

Appendix 5.3: 2SLS Regression for FDI effects by industrial category

	Industry Category			
	Resources-based	Labor-intensive	Metal & Chemical	Machinery
Intercept	1.71(0.13) [a]	1.22(0.14) [a]	5.32(0.24) [a]	6.22(0.34) [a]
lnK_{ijr}	0.81(0.01) [a]	0.84(0.01) [a]	0.47(0.01) [a]	0.44(0.02) [a]
$ln\ L_{ijr}$	-1.07(0.01) [a]	-1.02(0.01) [a]	-1.05(0.01) [a]	-1.03(0.02) [a]
$lnLE_{jr}\_1$	0.13(0.02) [a]	-0.15(0.02) [a]	0.04(0.04)	-0.11(0.16)
$lnUE_{r}\_1$	-0.45(0.05) [a]	0.14(0.07) [b]	0.09(0.12)	-0.02(0.04)
$COMP_{jr}$	0.33(0.02) [a]	0.25(0.02) [a]	0.01(0.03)	0.14(0.04) [a]
EXP_{ijr}	0.12(0.05) [b]	0.01(0.06)	0.11(0.09)	0.03(0.09)
IMP_{ijr}	0.05(0.05)	-0.04(0.06)	-0.29(0.07) [a]	0.01(0.08)
FDI_{ijr}	-0.20(0.07) [a]	0.08(0.08)	-0.17(0.10) [c]	0.08(0.09)
$SING_{ijr}$	-0.07(0.05)	-0.07(0.06)	-0.02(0.07)	0.01(0.09)
RND_{ijr}	0.66(0.04) [a]	0.93(0.06) [a]	2.34(0.18) [a]	1.69(0.53) [a]
R^2	0.759	0.732	0.543	0.593
F-Stat.	8219	5952	1262	743
Obs.(No.)	26,489	22,672	10,847	5019

Note: (1) [a], [b], and [c] denote a statistical significance at 1%, 5%, and 10% levels, respectively; (2) The numbers in parentheses are Heteroscedasticity-robust standard errors.
Source: Author's estimation

Appendix 6.1: Some characteristics of 53 PTC silk-weaving establishments

	Start-up	**Formal Regis.**	**Main products (90% or more of total sales)**	**Emp. (persons)**	**Weaving Machine (#)**	**Buyers & Sale Channels**	**Interview dates**
SE-1	1958	Yes	Light-weight, middle-weight, and heavy-weight fabrics; fabrics for decoration; *ikat* fabrics	25	Hand looms (22)	Export agent, own cloth shop, printing factory, hotels, trade fair	Aug. 11, 2007 Sep. 2, 2008
SE-2	1977	Yes	Light and middle-weight fabrics (plain and patterned); *ikat*; plain fabrics; men and women cloths, bed covers, pillow cases; neckties, men suits, scurf & shawl	20	Hand looms (18)	Export agent, own cloth shop, other cloth shops, printing factories, garment factories; trade fair	Aug. 15, 2007 Sep. 12, 2008
SE-3	1960	Yes	Light-plain and light-patterned fabrics, traditional *ikat*	12	Handlooms (10)	Export agent, cloth shops, printing factories; garment factories	Aug. 16, 2007 Sep. 8, 2008
SE-4	1976	Yes	Pain fabrics of all weights and various patterned fabrics or all weights (based on buyers' orders)	22	Electronic looms(16)	Export agent	Aug. 25, 2007 Sep. 6, 2008
SE-5	1985	Yes	Fabrics of various patterns and all weights, *ikat*, cloths, scurf & shawl, neckties, decoration fabrics	24	Electronic looms (4); Handlooms (12)	Export agent, garment factories; furniture factories, hotels, own retail store, trade fair	Aug. 27, 2007 Sep. 7, 2008
SE-6	1962	Yes	Light and middle-weight fabrics (plain and patterned); *ikat*; men and women cloths, scurf & shawl, bed & pillow covers, neckties, men suits, bags	20	Handlooms (20)	Own cloth shops, garment factories; printing factories, cloth shops, trade fair	Sep. 2, 2007 Aug. 31, 2008
SE-7	1967	Yes	Light-plain fabrics, decoration fabrics	20	Handlooms (15)	Export agent, garment factories; printing factories; trade fair	Sep. 3, 2007 Aug. 27, 2008
SE-8	1965	Yes	Light-plain and light-patterned fabrics, *ikat*, *khid*, cloths, men suits, scurf & shawl, traditional Thai women dresses	45	Handlooms (40)	Export agents, own cloth shop, garment factories; printing factories, trade fair	Sep. 3, 2007 Sep. 2, 2008
SE-9	1960	Yes	Light and middle-weight plain fabrics of various colors, *ikat*, cloths, traditional Thai dresses	25	Handlooms (17)	Export agents, own cloth shops, printing factories	Sep. 5, 2007 Aug. 29, 2008
SE-10	1972	Yes	Light and middle-weight plain fabrics of various colors, *ikat*, cloths, traditional Thai dresses	21	Handlooms (20)	Export agents, own cloth shops, printing factories, cloth shops, trade fair	Sep. 10, 2007 Sep. 7, 2008
SE-11	1965	Yes	Light and middle-weight fabrics (plain and patterned); *ikat*; men and women cloths, bed & pillow covers, men suits, scurf & shawl, bags, silk accessories	24	Handlooms (18)	Own cloth shops, own printing factory; garment factories	Sep. 15, 2007 Sep. 1, 2008
SE-12	1974	Yes	Light-weight plain fabrics	8	Handlooms (7)	Middleman	Sep. 20, 2007 Aug. 31, 2008
SE-13	1967	Yes	Light- and middle-weight plain fabrics	30	Handlooms (24)	Middleman, garment factories; cloth shops	Sep. 22, 2007 Sep. 4, 2008
SE-14	1987	Yes	Light-weight plain fabrics	20	Handlooms (20)	Middleman, cloth shops	Aug. 12, 2007 Sep. 1, 2008

	Start-up	Formal Regis.	Main products (90% or more of total sales)	Emp. (persons)	Weaving Machine (#)	Buyers & Sale Channels	Interview dates
SE-15	1986	Yes	Light- and middle-weight plain and patterned fabrics	100	Handlooms (75) Electronic looms (4)	Export agents, garment factories; printing factories, cloth shops	Aug. 12, 2007 Sep. 3, 2008
SE-16	2000	Yes	Light-weight plain fabrics, cloths, traditional Thai dresses	7	Handlooms (5)	Own cloth shop, other cloth shops, middleman	Aug. 13, 2007 Sep 9, 2008
SE-17	1973	No	Light-weight plain fabrics	28	Handlooms (26)	Middleman, cloth shops, furniture shops	Aug. 15, 2007 Sep 17, 2008
SE-18	2001	No	Traditional *Ikat*	6	Handlooms (4)	Middleman, cloth shops, trade fair	Aug. 15, 2007 Sep. 2, 2008
SE-19	1968	No	Light-weight plain fabrics; *ikat*	20	Handlooms (15)	Middleman, cloth shops, trade fair	Aug. 16, 2007 Sep. 7, 2008
SE-20	1992	Yes	Light-weight plain fabrics; geometric-patterned fabrics; women's traditional cloths	33	Handlooms (25)	Middleman, cloth shops; trade fair	Aug. 20, 2007 Sep. 6, 2008
SE-21	1991	No	Light-weight plain fabrics	25	Handlooms (22)	Middleman, cloth shops	Aug. 20, 2007 Sep. 14, 2008
SE-22	1998	Yes	Light-weight, middle-weight, and heavy-weight plain and patterned fabrics; decoration fabrics	33	Handlooms (20) Electronic looms (4)	Middleman, cloth shops; garment factories printing factories	Aug. 21, 2007 Sep. 11, 2008
SE-23	1998	Yes	Light-weight plain fabrics; *ikat*; cloths; pillow cases	20	Handlooms (17) Electronic looms (5)	Cloth shop (relatives); garment factories; export agent	Aug. 21, 2007 Aug, 24, 2008
SE-24	1992	No	*Ikat;* Thai traditional dresses	21	Handlooms (20)	Cloth shops; Middleman; trade fair	Aug. 22, 2007 Sep. 6, 2008
SE-25	1972	No	Light-weight plain fabrics; *ikat*	7	Handlooms (7)	Cloth shops	Aug. 23, 2007 Sep. 8, 2008
SE-26	1990	Yes	Patterned fabrics of all weights (based on orders); decoration fabrics	15	Electronic looms (9)	Export agents; garment factories; printing factories; hotels; furniture shops	Aug. 23, 2007 Sep12, 2008
SE-27	1968	No	Light-weight plain fabrics; *ikat*	35	Handlooms (30)	Cloth shops; middleman	Aug. 25, 2007 Aug.28, 2008
SE-28	1993	No	Light-weight plain fabrics; geometric-patterned fabrics	28	Handlooms (25)	Middleman; cloth shops	Aug. 25; 2007 Sep. 3, 2008
SE-29	1987	Yes	Plain fabrics and patterned fabrics of all weights; cloths; bed covers; neckties; bags; silk accessories	60	Handlooms (46)	Own cloth shops; export agent; printing factories; furniture shops; trade fair	Aug. 26, 2007 Sep. 8, 2008
SE-30	1968	No	*Ikat, khid*	10	Handlooms (8)	Cloth shops; trade fair	Aug. 31, 2007 Sep. 23, 2008
SE-31	1991	No	Light-weight plain fabrics	80	Handlooms (70)	Middleman; cloth shops	Sep 1, 2007 Sep. 21, 2008

	Start-up	Formal Regis.	Main products (90% or more of total sales)	Emp. (persons)	Weaving Machine (#)	Buyers & Sale Channels	Interview dates
SE-32	2002	No	Light-weight plain fabrics	100	Handlooms (80)	Middleman; cloth shops	Sep 2, 2007 Sep. 12, 2008
SE-33	1988	No	Light-weight plain fabrics	100	Handlooms (85)	Middleman; cloth shops	Sep 2, 2007 Sep. 17, 2008
SE-34	1987	Yes	Light-weight plain fabrics; *ikat*	30	Handlooms (25)	Middleman; cloth shops	Sep 5, 2007 Aug. 29, 2008
SE-35	1988	No	Light-weight plain fabrics	9	Handlooms (7)	Middleman; cloth shops	Sep 6, 2007 Sep. 13, 2008
SE-36	1987	No	*Ikat,* light-weight plain fabrics	12	Handlooms (10)	Cloth shops; trade fair	Sep 7, 2007 Sep. 7, 2008
SE-37	1990	1	Light-weight plain fabrics; *ikat*; traditional Thai dresses	30	Handlooms (25)	Own cloth shop; middleman	Sep. 8, 2007 Sep. 4, 2008
SE-38	1989	1	Light-weight fabrics (plain and geometric-patterned)	25	Handlooms (21)	Printing factories; cloth shops	Sep. 9, 2007 Sep. 15, 2008
SE-39	1981	0	Light-weight and middle-weight plain fabrics	35	Handlooms (33)	Middleman; cloth shops	Sep. 10, 2007 Sep. 19, 2008
SE-40	2002	1	*Ikat* (traditional styles)	9	Handlooms (9)	Own cloth shop; trade fair	Sep. 13, 2007 Sep. 10, 2008
SE-41	1984	0	Light-weight plain fabrics	24	Handlooms (23)	Cloth shops; Middleman	Sep. 5, 2008
SE-42	2001	0	Light-weight plain fabrics	25	Handlooms (20)	Cloth shops; Middleman	Sep. 6, 2008
SE-43	1986	1	Light-weight and middle-weight plain and patterned fabrics; decoration fabrics; *Ikat*; traditional Thai dresses	32	Handlooms (25)	Own cloth shops; other cloth shops; garment factories; printing factories; trade fair	Sep. 8, 2008
SE-44	1990	1	Plain and patterned fabrics of all weights; *Ikat*	20	Handlooms (12) Electronic looms (2)	Garment factories; printing factories; middleman; trade fair	Sep. 9, 2008
SE-45	1992	0	*Ikat*; light-plain fabrics	7	Handlooms (6)	Middleman	Sep. 10, 2008
SE-46	1986	0	Light-plain fabrics	24	Handlooms (21)	Middleman; cloth shops; trade fair	Sep. 12, 2008
SE-47	2006	0	*Ikat* (traditional and modern)	8	Handlooms (7)	Cloth shops	Sep. 12, 2008
SE-48	1989	0	Light-plain fabrics; traditional *ikat*	26	Handlooms (21)	Middleman; cloth shops; garment factories; furniture shops	Sep. 13, 2008
SE-49	2002	1	Light-weight fabrics (patterned and plain); *ikat; khid*; cloths; pillow cases; scurf & shawl, traditional Thai dresses	30	Handlooms (28)	Own cloth shop; printing factories; export agent; trade fair	Sep. 15, 2008

	Start-up	Formal Regis.	Main products (90% or more of total sales)	Emp. (persons)	Weaving Machine (#)	Buyers & Sale Channels	Interview dates
SE-50	1990	0	Light-weight plain fabrics	28	Handlooms (23)	Cloth shop (relatives); middleman; garment factories; trade fair	Sep. 15, 2008
SE-51	1994	0	Light-weight and middle-weight plain fabrics; *ikat*	31	Handlooms (27)	Middleman; garment factories; printing factories; cloth shops	Sep. 19, 2008
SE-52	1996	0	Light-weight plain fabrics	26	Handlooms (23)	Middleman;	Sep. 21, 2008
SE-53	2002	0	Light-weight plain fabrics; *ikat*	18	Handlooms (16)	Middleman; trade fair	Sep. 24, 2008

Source: Author's interviews

Appendix 6.2: Comparing performance of JT's former subcontractors and non-JT's former subcontractors by age group

Panel a. JT's former subcontractors versus Group 1

Variables	JT's former Subcontractors ($\bar{x}_1$)	Group 1 ($\bar{x}_2$)	M-W Test
Performance			
1. Labor(L)	22.8	22.7	47.5(0.28)
2. Output(O)	3,062	1,697	27.0(0.02) [b]
3. Sales(S)	756,548	300,061	23.0(0.01) [a]
4. Profit	191,781	37,208	11.0(0.00) [a]
5. Profit margin (%)	28.2	14.9	21.5(0.01) [a]
6. Labor productivity(O/L)	133.6	82.9	20.5(0.00) [a]
7. Labor productivity(S/L)	33,144	16,180	12.0(0.00) [a]
Sample size	13	12	

Note: (1) [a] and [b] denote statistical significance at 1% and 5% levels, respectively; (2) Variables for comparison are defined as in Table 6.11; (3) Group 1 = SE-19, SE-25, SE-27, SE-29, SE-30, SE-34, SE-36, SE-39, SE-41, SE-43, and SE-46. *Source*: Author's calculation

Panel b. JT's former subcontractors versus Group 2

Variables	JT's former Subcontractors ($\bar{x}_1$)	Group 2 ($\bar{x}_2$)	M-W Test
Performance			
1. Labor(L)	22.8	33.6	114.5(0.57)
2. Output(O)	3,062	3,327	119.0(0.70)
3. Sales(S)	756,548	629,693	93.0(0.18)
4. Profit	191,781	85,587	56.0(0.01) [a]
5. Profit margin (%)	28.2	12.9	35.0(0.00) [a]
6. Labor productivity(O/L)	133.6	107.7	76.5(0.04) [b]
7. Labor productivity(S/L)	33,144	21,519	49.0(0.00) [a]
Sample size	13	28	

Note: (1) [a] and [b] denote statistical significance at 1% and 5% levels, respectively; (2) Variables for comparison are defined as in Table 6.11; (3) Group 2 = establishments not include in Group 1 and in JT's former subcontractors. *Source*: Author's calculation

Panel c. Group 1 versus Group 2

Variables	Group 1 ($\bar{x}_1$)	Group 2 ($\bar{x}_2$)	M-W Test
Performance			
1. Labor(L)	22.7	33.6	64.5(0.12)
2. Output(O)	1,697	3,327	45.5(0.02) [b]
3. Sales(S)	300,061	629,693	44.0(0.01) [a]
4. Profit	37,208	85,587	59.0(0.07) [c]
5. Profit margin (%)	14.9	12.9	89.0(0.65)
6. Labor productivity(O/L)	82.9	107.7	64.0(0.12)
7. Labor productivity(S/L)	16,180	21,519	63.0(0.10) [c]
Sample size	12	28	

Note: (1) [a] , [b] , and [c] denote statistical significance at 1%, 5%, and 10% levels, respectively; (2) Variables for comparison are defined as in Table 6.11. *Source*: Author's calculation