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Foreign Direct Investment and Local Firm Productivity: Evidence from Thailand

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I am submitting herewith a dissertation written by Sasima Wongseree entitled "Foreign Direct Investment and Local Firm Productivity: Evidence from Thailand." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Economics.

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Foreign Direct Investment and Local Firm Productivity: Evidence from Thailand

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Dedication

To my parents, Sunan and Supathida Wongseree.

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Abstract

The enormous costs incurred to government for foreign direct investment (FDI) inflows raised question whether its benefits are worthwhile. In this dissertation, I use productivity estimates as outcomes to explore the direct and indirect impacts of FDI inflows on local firms in manufacturing sector of Thailand during 2001 to 2006.

Chapter 1, I introduce the overview of the entire dissertation.

Chapter 2, I briefly reviewed investment climates and FDI conditions in Thailand. Then I constructed a comprehensive firm-level dataset from several data sources for FDI examination. The main dataset offers quantity and capacity outputs along with revenues at product-level.

Chapter 3, I modify two existing productivity estimation approaches to compute firm productivity in terms of value added, quantity and full capacity outputs. The new productivity estimation approach corrects for endogeneity, multicollinearity and allows for multi product firm assumption. The production function coefficients from the new model exhibit unskilled labor intensive technology in all sectors.

Chapter 4, with productivity estimates from chapter 3, I examine the FDI direct impacts on productivity of local affiliates. I adopt two selection bias correction methods: average treatment effects on the treated based on propensity score matching (ATT), and a control function based on second moment conditions proposed by Farre, Klein and Vella (2009). The results from ATT exhibit the existence of FDI direct effects in ten sectors. The results from the second method are significant in eleven sectors. This finding suggests that FDI direct effects depend on specific factors across sectors.

Chapter 5, I investigate whether FDI spillovers exist through horizontal and vertical relationships. The agglomeration-spatial weights are introduced in spillover variables to capture the contributions of clusters and geographical distances. When controlling for agglomeration and geographical distance, the results indicate positive spillover effects through backward linkages, and negative effects through forward linkages and horizontal relationships. This finding reflects the positive benefits from FDI to Thai suppliers, negative impacts on Thai buyers and

competitors who located close to clusters. This means FDI spillover exists only when FDI firms are located close to clusters.

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Chapter 1

General Introduction

1.1 General Introduction

Foreign Direct Investment (FDI) has played an crucial role in economic development in many countries as it is an important source of productivity growth. Theoretically, there are many potential benefits that FDI may contribute to the host countries. For instance, foreign investors may transfer their financial resource and technological knowledge to local partners in the host countries which improve productivity of these local firms. These productivity improvement may be dispersed to other locally-owned firms through market competition or intermediate input transaction. However it is not clear whether these expected benefits would occur in the host countries because there are several determinant factors that vary across countries. The main objective of this dissertation is to examine the relationship between FDI inflows and development through productivity of local firms.

There are three major tasks in any examination of FDI impacts on productivity. First task is to construct a comprehensive dataset that contains firm-level production information, FDI inflow variables as well as macroeconomic variables. Then the measure of productivity is needed as the outcome variables. Lastly, the identification of transmission channels and the proper examination methodology are needed to frame the analysis.

In Chapter 2 of this dissertation, I review investment climate in Thailand and elaborate how I collect data from several data sources to construct a comprehensive firm-level dataset from Thailand during 2001 to 2006. The special feature of this dataset is that it provides information on quantity and full capacity outputs along with revenue of each product line at firm-level.

Then, in Chapter 3, I develop firm productivity estimation method that corrects for traditional econometric issues in production function estimation. I modify and combine two existing production estimation approaches to correct for endogeneity and multicollinearity under monopolistic competition. The first approach, proposed by Ackerberg et al. (2006), corrects for endogeneity and multicollinearity. The second approach, proposed by De Loecker (2007), corrects for endogeneity and allows for multi product firms. With the data from Chapter 2, I estimate productivity with three types of outputs: value added, quantity and full capacity outputs. The results of production function estimation indicate that the coefficients from the combined model are larger than the other models. This evidence reflects the importance of multi product firm assumption and multicollinearity correction. Then I use the productivity estimates from Chapter 3 as the outcome measures for FDI effect examination.

I identify two transmission channels of FDI benefits including direct and indirect effects. Previous literature usually ignored the direct effect and intensively explored the indirect or spillover effect although the spillover is the consequence of the direct effect. In Chapter 4, I investigate whether FDI direct effects exist. I adopt two econometric methods to control for selection bias in FDI direct effect examination. First, I use average treatment effect based on propensity score matching. This method relies on observed variables to control for selection bias. The second method employed in Chapter 4 is proposed by Klein and Vella (2009) which allows the control variable to relies on the unobserved factors. I follow Farre et al. (2010) to compute the control variable. The results from both methods suggest that FDI direct effects vary across sectors.

In Chapter 5, I examine the spillover effect which is the impacts from FDI inflows to other Thai firms who did not receive foreign share during the sample period. I follow Javorcik (2004)'s spillover specification by identifying horizontal and vertical relationships as spillover transmission channels. The horizontal relationship transmits the knowledge from FDI to locally-owned firms through market competition within a given sector. The vertical relationship passes the knowledge from FDI to other firms through intermediate input transaction. I modify Javorcik (2004)'s calculation strategy by introducing agglomeration-spatial weights into spillover variables. The new spillover variables capture contribution of proximity to clusters of competitors, buyers and suppliers on spillover effects. The results exhibit the existence of FDI spillover through both horizontal and vertical relationships when controlling for the contribution of agglomeration and geographical distance. The findings suggest positive FDI spillovers through backward linkages which are the impacts from FDI inflows to buyer sectors on productivity of Thai firms. In addition, the results show negative FDI spillover through horizontal relationship and forward linkages which are the impacts from FDI inflows to the competitors and suppliers on productivity of Thai firms.

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Chapter 2

Foreign Direct Investment in Thailand: For Better or Worse?

2.1 Foreign Direct Investment and Economic Development

Foreign Direct Investment (FDI) has become an important factor in economic development because it potentially brings about job creation, technological improvement, and market competition which stimulate long-term economic growth. These potential benefits, which will be directly transferred to FDI recipients in host countries are financial supports, marketing facilities, and technological and managerial knowledge. Furthermore, other local firms that do not receive FDI may benefit from its existence due to spillover effects.

Theoretical predictions of FDI effects are inconclusive because of many determinant factors that vary across countries (Crespo and Fontoura (2007)). Moreover, multinational firms may not transfer their key technological knowledge and marketing property, which could be their core competence, to local affiliates in order to preserve advantages over local firms. Hence there is no guarantee that local firms will ultimately gain this knowledge and improve their productivity. In some circumstances, FDI may even worsen the productivity of local firms (Lipsey (2002)). For instance, FDI firms with costly advanced technology may not let local staff access this knowledge which prevents technology spillover through the labor mobility channel. The other local firms that have limited financial sources may not adopt the new technology and become less productive.

The potential benefits of FDI lead many countries to exert efforts in seeking for FDI even if it might incur enormous expenses in the form of fiscal resources, government revenue loss from tax incentives and conducive investment environment. The necessity of self-incurred upfront costs for FDI inflows despite its questionable consequences, raises questions for policymakers if all the attempts are worthwhile. Therefore, it leaves room for empirical research to answer such questions.

In my thesis, I examine FDI effects on local firms in manufacturing sectors in Thailand using firm-level data during 2001-2006. Thailand is a great choice for exploring FDI effects to a host country because it has had a large share of FDI inflows to Southeast Asian countries in the past decade. In the next section, I review information on FDI inflows to Thailand as well as Thai important characteristics that may determine FDI effects.

2.2 Thailand and Foreign Direct Investment

The financial crisis during 1997-98 in the Southeast Asia pressured countries in the region to accept financial aid from the International Monetary Fund (IMF). This financial support came with policy interventions that opened opportunities for multinational enterprises to own Asian firms and assets. The relaxation of financial restrictions in these countries has brought about the influx of FDI to this region. Figure 2.1 shows that developing countries in Asia took the largest share of FDI during the past decade.

The surge of FDI inflows to the region after the financial crisis can be attributed in part by the ASEAN investment area (AIA) agreement[1] and unrestricted financial transaction policies. This agreement facilitates investment and production cooperation among member countries, which opens up the opportunities to initiate cross-country production cooperation. As a result, multinational enterprises that engage with local affiliates in the member countries may also benefit from the agreement.

Similar to other developing countries after the financial crisis, the great depreciation of Thai currency and less restricted financial transaction regulations attracted tremendous FDI inflows to Thailand. In addition, Thailand has rewarded privileges such as tax incentives, material import duty exemption, and reduction to FDI projects that contribute to the development of skills, technology and innovation.[2]

In addition to investment policies, the locational advantages also play important roles in attracting FDI to Thailand. Sufficient infrastructure and convenient distribution channels to several neighboring countries entice multinational firms that seek market accesses to establish production

[1] Framework Agreement on ASEAN Investment Area. http://www.aseansec.org/6466.htm.
[2] Thailand Board of Investment http://www.boi.go.th/index.php?page=thailand_advantages

bases in Thailand.[3] Kohpaiboon (2003) and Piyaareekul Uttama and Peridy (2010) found evidence supporting the fact that foreign firms in Thailand were horizontal multinationals and that Thai promotion of export-oriented industries attracted these types of foreign investors.[4]

The key weakness of Thailand is that it has had occasional political chaos in the past decade. According to World Bank (2008), political instability is the most severe obstacle of investment. However, FDI inflows into the Thai manufacturing sectors remained high relative to other developing countries in the region.

Another disadvantage is that Thailand no longer has advantage of cheap labor. From the same report, the skilled labor shortage is the biggest obstacle for doing businesses in Thailand. Two surveys carried out for this World Bank report indicate that approximately 40% of business had lower performance problems due to skilled labor job vacancies unfilled and less qualified labor. FDI existence may induce this problem because FDI firms may pay higher wages for high skilled workers and absorb the top quality skilled workers in the market, which in turn raises wages of skilled labor so high that Thai firms cannot afford to hire good quality skilled workers.

This incident follows the predictions of capital mobility models. For instance, the simple capital inflow model by MacDougall (1960) predicts that capital inflow increases wages in the host country, and the Knowledge-Capital Model by Markusen and Maskus (2002) predicts that an increase in FDI will raise wages of skilled labor in both the home and host countries[5].

Although Thailand has some weaknesses, its advantages, along with FDI favorable policies, have attracted more FDI inflows than other ASEAN countries. Figure 2.2 and Table 2.1 show a striking increase in FDI inflows to Thailand from 3,882 million USD in 1997 to 7,492 million USD in 1998 while FDI flow to other neighboring countries sharply dropped. Between 2000-2002, FDI

[3] For example, Thailand have borders with four potential markets; Malaysia, Myanmar, Laos and Cambodia which makes Thailand an attractive location for distribution warehouses to these countries. Moreover Thailand also provides world class ports in two locations, Bangkok and Laem Chabang, and three regional ports supporting transportation among six countries along Mekhong River, i.e., Thailand, China, Laos, Vietnam, Myanmar, and Cambodia.

[4] Both studies employ macro level data which may not fully capture vertical relationships.

[5] Feenstra (2004)(chapter11, p376-395)

inflow to Thailand fluctuated from 3,000 - 5,000 million USD due to the national election in 2000 and the 9/11 shock in the U.S. in 2001, which slowed down investment flow worldwide. However, in the following years, FDI inflow to Thailand bounced back over 5,000 million USD in 2003 and tripled to over 9,000 million USD in 2006. Surprisingly, Thailand's GDP growth rates during 1998 to 2005 were not drastically different from other countries in the region[6], even though it had significantly greater FDI inflows. The evidence indicates that Thailand has been hosting FDI in manufacturing sectors for decades, however, it is not clear whether FDI inflows benefit local firms.

With respect to FDI fluctuations in manufacturing sectors, Table 2.2 shows that FDI inflows to these sectors declined more than 40% from 3,161 million USD to 1,633 million USD during 2000 to 2002 due to political instability and then rebounded to 3,675 and 4,949 million USD in 2003 and 2004 respectively. By 2006, many trade agreements had been established between Thailand and trade partners which went into effect in a few years later. This factor attracted even more FDI inflows in 2005.

All attempts for FDI inflows draw critical questions how FDI benefits economic agents. It is expected that local affiliates should improve their productivity since they directly receive financial and technological transferred from FDI. If there is any direct benefit occurring, firms in the high FDI concentration sectors should receive it more than other sectors. During the sample period, Table 2.2 shows that there are six manufacturing sectors in Thailand that received FDI inflows higher than 1,000 million USD. These sectors include chemicals, rubber and plastic products, fabricated metal products, machinery, communication equipment, and motor vehicles, which received 2,479 million USD, 1,436 million USD, 2,959 million USD, 7,528 million USD and 4,524 million USD respectively. Among these sectors, communication equipment and motor vehicles took the largest shares and have more FDI firms than local firms while other sectors have the reverse pattern. All highly concentrated FDI sectors require considerably high start-up costs and advanced technol-

[6]From World Bank's Investment Climate Report, Thailand had average GDP growth rate of 2.5 percent while that of East Asia and Pacific was 6.5 percent.

ogy in the production process. This requirements discourage Thai investors and open investment opportunities for foreign multinationals.

In the FDI effects examination, I employ firm-level data from manufacturing sectors in Thailand during 2001-2006. In addition to the primary dataset, I gathered necessary information from eight data sources and construct a comprehensive dataset. In the next section, I briefly describe the data sources and their usage in the analysis.

2.3 Data Sources

To construct the dataset used for the assessment of foreign direct investment outcomes in Thailand, I gathered data from eight sources, two of which give firm-level information while the others provide sectoral data. The sample period in the main dataset is from 2001-2006. Each data source classifies firms and production sectors differently. I have to recategorize all datasets into two-digit ISIC.[7]

2.3.1 The Annual Survey on Thailand's Industries

The main dataset is an unbalanced dataset from the annual survey on Thailand's Industries arranged by the Office of Industrial Economics (OIE), Ministry of Industry from 2001-2006. The special feature of this dataset is that the respondents report physical outputs and capacity, which are rarely observed in other datasets, as well as revenue. From the OIE dataset, I employ firm production value, production quantity, number of product lines each firm produces, domestic and imported material costs, machinery and equipment values, machinery age structure, skilled and unskilled workers per year, percentages of Thai owned shares and foreign shares of the firms' equity.

The information in this dataset is classified at industry level, with a four-digit ISIC. However, the analyses in the following chapters are based on sectoral level, two-digit ISIC, because of in-

[7]ISIC stands for International Standard Industrial Classification. In this thesis, I use Revision 3 provided by United Nations Statistics Division.

sufficient observations in some industries. I ignore observations that cannot be categorized in any industry as well as the observations with unreasonably high/low values.

The weakness of this dataset is the sample size. Comparing with datasets in other similar studies, the Thai datasets is small because the survey is not mandatory and the questions are meticulous which brought in low return rate of questionnaires. As shown in Table 2.3, the share of total sales in the dataset to total sales in the census varies from 11% to 80%, and the share of firms in the data to total active firms is about 10% within the six year sample period. Other similar studies have larger sample sizes. For example, Indonesian data used in Blalock and Gertler (2008) has 15,800 firms over eight years, Lithuania data used in Javorcik (2004) captures 85% of total output in each sector over five years, Chilean data used in Levinsohn and Petrin (2003) and Ackerberg et al. (2006) has 9,670 observations for the four largest sectors over seven years.

Even though the sample size is small, aggregate revenue in the dataset captures substantial market share in total sales of all active firms, as shown in Table 2.3. Obviously, aggregate sectoral sales in the dataset represents considerable market activities in many sectors. For example, the number of total operating firms in the food sector is extremely large, and the share of firms in the data to the total active firms is only 2%, but its aggregate sales in the dataset accounts for more than 40% of total sales in the market. Ignoring very small firms, the share of firms in the food sector in the dataset captures about 15 percent of overall operating firms, which is much larger than the firm share when including very small firms. A similar pattern occurs in all other sectors. This substantial market share with the small sample size may imply an abundance of medium and large firms in the dataset even though the majority of producers in the market are much smaller. In the sample, it is possible that the majority of firms are medium to large sizes, and have registered funds of at least one million Bahts.

To affirm that the dataset consists of mostly medium and large firms, Table 2.5 categorizes firm distribution into three groups by registered capital value: lower than one million Bahts, at least one million to a hundred million Bahts, and greater than a hundred million Bahts. Clearly, all sectors have more medium and large firms than small firms. Even sectors that do not require high start-up costs, such as food and wearing apparel, have more medium and large firms than small ones. As expected, the sectors that need considerably large start-up costs and advanced technology production processes like the communication equipment sector, which took the largest FDI inflows, has more firms in group three than the other groups. It can be inferred from Table 2.5 that most firms in this data set are medium and large firms, which may not represent the majority of active firms in the population.

Table 2.3 shows that the aggregate revenue of firms in the communication equipment and motor vehicles sectors in the dataset account for about 60% and 30% of actual total sectoral sales, respectively, while the machinery sector in the dataset captures about 80%. Regarding this issue, the interpretation of the results in this thesis may not represent the effects occurred to small firms.

2.3.2 Factory Registration Database

In addition to the main dataset, I use some firm characteristic variables from the factory registration database. By law, all plants operating in Thailand must apply for establishing permission and register with the Department of Industry Work (DIW). This dataset provides registration numbers, firms' zip codes, product details, establishing years, machinery values, registered funding, and production workers. I matched firms in the datasets from OIE and DIW based on registration numbers.

I can track the exited firms at any time in the sample period so that the selection bias due to exit decision can be avoided. As it turns out, there are only 43 firms in the dataset that dropped out because of exit decisions. Consequently, I excluded these firms from the analysis.

2.3.3 Producer Price Indices

All variables in nominal terms are deflated with the producer price indices. These producer price indices are provided by the Bureau of Trade and Economic Indices, Ministry of Commerce. They are classified into 180 sub industries which need to be recategorized into four-digit ISIC. The deflators are estimated by the weighted average of inverse price indices.

2.3.4 FDI Statistics

I gather FDI inflow data at the sectoral level from the ASEAN FDI database to assess FDI impacts on local firms in Thailand in Chapters 4 and 5. However, this database does not provide information for the entire sample period, and therefore FDI inflow data from the Bank of Thailand fills in the last year of the sample period. The drawback of FDI data from the Bank of Thailand is that only seven major sectors are provided. I recovered FDI inflow of the other industries based on average share of total FDI during the five prior years.[8]

2.3.5 Input-Output Table

In Chapter 5, I will examine FDI indirect effects which are measured by productivity spillover from FDI to locally-owned firms. These indirect effects can be dispersed to firms within and across sectors. The transmission channels that I focus on are the backward and forward linkages which reflect intermediate input transaction across sectors. To examine the spillover, I compute backward and forward variables from the Input-Output Table provided by the Office of National Economic and Social Development Board. The Input-Output Table of Thailand consists of 180 sectors which are not classified in ISIC. Similar to the estimation of producer price indices, economic sectors in the Input-Output Table are recategorized to conform with two-digit ISIC.

2.3.6 Distance

The dispersion of FDI effects could partially depend upon the distance between firms and their suppliers or buyers in other sectors. It is possible that firms in close distances may learn from FDI

[8] I calculate average share of FDI inflow to each sector from 2000 - 2005 and then multiply it with the total FDI inflow to Thailand in 2006 provided by the Bank of Thailand

firms easier than the firms located further away. In addition, supplier and buyer firms who locate nearby each other tend to have more connections because of lower transportation costs. To capture this effect, I construct a spatial weights from the distance between every pair of 76 provinces.[9] The distance data can be downloaded from the Department of Highways, Ministry of Transport, Thailand.

2.3.7 Map

The influence of geographic attributes on firms' decisions may also impact FDI spillover. Firms may cluster in some locations to enjoy location specific benefits such as output markets, economies of scales, access to input sources or connections with suppliers/buyers. Therefore, I explore whether or not there are clusters of firms in each sector across geographic spaces. To do so, I need the map of Thailand to plot firm distributions of each sector across provinces.

The map data of Thailand is downloaded from the DIVA-GIS website which provides spatial data for all countries. I use map data of the administrative areas to generate base maps and then incorporate the number of firms in each sector located in each province to analyze firm clusters across provinces.

2.4 Statistical Description

In the following chapters, different sets of variables are employed. The objective of Chapter 3 is to compute corrected productivity estimates. I use three types of outputs: value added, quantity and capacity outputs as well as input variables from the main dataset. In addition, I use foreign share in total equity of firms and firms characteristic variables from the main dataset and the Factory Registration Database. I employ FDI inflows to each manufacturing sector of Thailand during 2001-2006 in Chapter 5. In this section, I elaborate on firm distribution and statistic descriptions

[9] The distances are measured from city hall -to- city hall of each pair of provinces.

of variables for the following chapters.

2.4.1 Firm Distribution and Cumulative FDI Inflows

As mentioned, the main dataset is an unbalanced panel. Before cleaning data, 4,085 firms returned the survey during 2001-2006 which gave 14,769 firm-year observations within 22 sectors. Since the following chapters focus on FDI effects, I drop the sectors that did not receive FDI inflows during the sample period. The tobacco sector is dropped from the dataset because there is legal protection that allows only Thai entrepreneurs to operate in this sector during the sample period, and thus there was no FDI inflows to this sector. Similarly, I also ignore the manufacture of accounting machines and recycling sectors, because they did not receive FDI inflows during the sample period, even though there were no regulations discouraging foreign investment. In addition, two more sectors are excluded due to convergence problems in the productivity estimations.

After the cleaning process, the data set contains 3,599 firms with 13,748 observations in 17 sectors. Table 2.4 shows the distribution of firms, observations classified by sectors, ownership, and cumulative FDI inflows in dollar terms during the sample period. Low start-up cost sectors have observations and number of firms greater than those of the high start-up cost sectors. For instance, the food sector, one of the low start-up cost sectors, has 577 local firms with 1,957 observations and 138 FDI firms with 429 observations while the communication equipment sector, which requires large amount of start-up cost and advanced production technology, has 99 local firms with 240 observations and 120 FDI firms with 385 observations.

2.4.2 Variables in Productivity Estimation

The special feature of the main dataset is that it provides physical output and full capacity physical output level along with revenue. I employ all three types of outputs to estimate productivity. For comparison, productivity estimates in terms of value added and quantity will be outcome measures in the FDI effect analysis. As in the traditional production function estimation, labor and capital are fundamental production inputs. In the dataset, there are four types of workers classified by education: professional (bachelor degree and above), skilled (at least high school but lower than bachelor degree), unskilled(lower than high school), and others (workers who do not work in production), where all types of workers are reported in man-year units. I add up professional and skilled workers for skilled labor inputs and use unskilled labor as reported. The deflated value of machinery and production equipment will be used as capital input. In the productivity estimation, I use deflated material costs as the intermediate input as suggested by Levinsohn and Petrin (2003). I follow De Loecker (2007) by including the number of product lines into the productivity estimation so that monopolistic competition is allowed. Table 2.6 shows variations of variables in the productivity estimation.

All outputs of Thai firms have lower means but larger standard deviations compared with FDI firms. Similarly, the skilled labor and machinery values of Thai firms have lower means but larger standard deviations relative to FDI firms. In contrast, the standard deviations of unskilled labor, material costs and the number of product lines of Thai firms are slightly lower than those of FDI firms.

Six sectors received FDI inflow of over 1,000 million dollars during the sample period. These sectors require considerably high start-up costs and advanced production technology, and hence their input values should be higher than low-FDI concentration sectors. As expected, the means of value added and all inputs of high FDI concentration sectors are higher than those of low FDI sectors.

2.5 Firm Distribution by Provinces

Figures 2.4-2.19 depict the distributions of firms in the dataset across provinces by sectors. In these maps, darker areas reflect higher number of firms in that province. From the maps, it is obvious that Bangkok is the most desirable location for manufacturers in all sectors. This is expected because Bangkok provides prominent advantages over other provinces. For example, Bangkok is the capital of Thailand with a population of 14 million which makes it the largest market in the country. Secondly, it is located in the central part of the country, where the average distance to every province is lower than in any other city. This geographical characteristic of Bangkok attracts firms who try to minimize domestic transportation costs.[10]

Due to industrial zoning policies, the further from Bangkok that the firms locate, the more privileges they receive. There exist some clusters in other big cities as well. Moreover, the large provinces at border lines, where trade opportunities with neighboring countries are flourish, are also desirable locations to the firms. This brings about clusters in those provinces. For example, Chiang Mai, the largest city in the northern region, located at the border with Myanmar, hosts clusters in food and wearing apparel sector. Songkhla, the second largest city in the southern region located at the border line with Malaysia, hosts clusters in food and rubber product sectors, and Nakhonpanom, locating at the border with Laos, hosts clusters in food and textile sectors.

This evidence follows the predictions of the geographic concentration model proposed by Krugman (1991). The key predictions of this model are that firms who minimize transport costs choose to locate in the largest demand location and transport outputs to other markets and that the largest market demand is the location where the majority of the manufacturers located. It turns out that although the number of firms in the dataset is very small compared to the total active firms in the population, they reflect conventional behaviors on location choices.

In addition, the specific characteristics in each region also play important roles in clustering of manufacturers. For example, the climate in the north is relatively colder than other parts which is suitable for silkworms. This area hosts clusters of the wearing apparel sector while a cluster of this sector is not found in the south where the precipitation level is high all year long. However, this consistent humidity is suitable for rubber trees making the south a perfect place for the rubber sector. One special case is in ceramic industry. Lumpang, a province in the north, is endowed with

[10] See locations of provinces in Figure 2.3.

good quality clay which is the best raw material for ceramics. It hosts a cluster of ceramic industry, part of the non-metallic mineral product sector.

From this information, it is obvious that the effects of geographic specific are distinct in the dataset. Therefore the geographic specific will be included in FDI spillover analysis in Chapter 5.

2.6 Conclusion

It is believed that foreign direct investment (FDI) will generate positive effects for host countries, however, there is no guarantee whether those positive benefits will occur. In particular, local firms in the host country may or may not benefit from the existence of FDI. In some circumstances, local firms may be worse off after FDI firms enter. The expected positive effects from FDI lead many countries to exert efforts to attract FDI which incurs extremely large costs such as supply of infrastructures, government revenue loss from tax incentives, and the creation of the business environment. The tremendous costs in return for FDI question whether FDI actually benefits the host countries. I investigate this question using the comprehensive firm-level data from manufacturing sectors in Thailand from 2001-2006.

The main dataset is an unbalanced dataset from the annual survey on Thailand's industries arranged by the Office of Industrial Economics (OIE), Ministry of Industry. I gathered data from other sources to accompany the primary dataset. The novelty from the new comprehensive dataset is that it provides detailed information which are rarely observed in other datasets, such as quantity of output, capacity of output, variety of product lines, and domestic/imported material costs, etc. I also combine geographic information with the main dataset that will play important role in the FDI effect examination.

In Chapter 3, I use the dataset constructed here to estimate firm productivity in terms of value added and quantity which has not been widely done in the previous studies. Then, I examine FDI effects in Chapters 4 and 5 using productivity estimates from Chapter 3 and other information from the Thai dataset.

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Table 2.1: FDI Inflows to ASEAN during 1995-2006

Million US Dollars

year	Thailand	Malaysia	Indonesia	Philippines	Vietnam	Cambodia	Brunei	Myanmar	Laos	Timor-Leste	Indonesia w/East Timor
1995	2,070	5,815	0	1,459	1,780	151	583	318	88	0	4,428
1996	2,338	7,297	0	1,520	1,803	294	654	581	128	0	6,245
1997	3,882	6,323	0	1,249	2,587	168	702	879	86	0	4,729
1998	7,492	2,714	0	1,752	1,700	238	573	684	45	0	-207
1999	6,091	3,895	0	1,247	1,484	232	748	304	52	0	-1838
2000	3,410	3,788	0	2,240	1,289	149	549	208	34	0	-4495
2001	5,073	554	0	195	1,300	149	526	192	24	0	-2842
2002	3,355	3,203	0	1,542	1,200	145	1035	191	25	0	233
2003	5,222	2,473	-507	491	1,450	84	3375	291	19	5	0
2004	5,859	4,624	1,896	688	1,610	131	334	251	17	3	0
2005	8,067	4,064	8,336	1,854	2,021	381	289	236	28	0	0
2006	9,517	6,060	4,914	2,921	2,400	483	434	428	187	8	0

Source: UNCTAD

Table 2.2: FDI Net Inflows to Thailand by Industry during 2000-2006

	FDI Inflows					(Million	US Dollars)
ISIC	2001	2002	2003	2004	2005	2006	Total
15 Food	171.28	69.34	116.96	171.38	113.02	118.13	760.11
17 Textiles	59.61	72.99	53.11	81.73	24.99	-7.88	284.55
18 Wearing apparel	7.39	6.19	8.74	9.29	21.55	15.96	69.12
19 Tanning and dressing of leather	8.57	4.92	14.05	1.66	5.52	4.65	39.37
20 Wood and products of wood	3.42	5.21	1.13	35.63	3.43	2.29	51.11
21 Paper and Paper products	9.49	7.96	17.71	205.28	7.17	5.03	252.64
22 Publishing and printing	3.75	10.09	5.66	2.5	11.49	10.55	44.04
24 Chemicals and chemical products	771.09	64.94	646.4	416.45	406.22	173.95	2,479.05
25 Rubber and plastic products	231.76	97.51	174.19	295.26	336.3	301.75	1,436.77
26 Non-metallic mineral products	25.87	26.74	66	73.21	50.7	45.69	288.21
27 Basic metals	46.03	7.17	205.64	85.92	62.05	53.79	460.60
28 Fabricated metal products	304.79	83.78	152	261.88	339.69	304.65	1,446.79
29 Machinery and equipment	167.94	358.29	493.63	715.09	1048.42	175.9	2,959.27
31 Electrical machinery and apparatus	13.46	85.11	24.01	37.46	36.24	24.51	220.79
32 Communication equipment and apparatus	1,053.91	530.32	864.1	2,047.81	1,951.73	1,080.91	7,528.78
34 Motor vehicles	70.01	124.79	806.8	474.98	1,644.69	1,402.81	4,524.08
36 Furniture	119.52	10.2	21.71	57.43	59.95	31.5	300.31
Others	93.71	68.43	6.19	6.57	26.33	347.78	
Total	3,161.60	1,633.98	3,678.03	4,979.53	6,149.49	4,091.97	23,145.59

Table 2.3: Firm Shares and Sectoral Market Shares in 2006

Sector	(1) Total Operating Firms	(2) Medium and Large Firms	(3) Firms in Sample	$\frac{(3)}{(1)} \times 100$ Firm Share a	$\frac{(3)}{(2)} \times 100$ Firm Share b	Sample Market Share to Sector Total Sales (%)
15 Food	24,296	3,783	658	2.37	15.25	44.3
17 Textiles	4,485	1,494	384	7.47	22.42	19.5
18 Wearing apparel	4,492	2,184	257	4.92	10.12	20.3
19 Tanning and dressing of leather	1,838	743	104	5.33	13.19	31.9
20 Wood and products of wood	9,331	864	79	0.81	8.80	13.9
21 Paper and Paper products	1,464	922	120	7.10	11.28	27.3
22 Publishing and printing	2,200	1,896	112	4.64	5.38	11.9
24 Chemicals and chemical products	3,277	1,420	236	5.46	12.61	64.6
25 Rubber and plastic products	9,625	2,583	384	3.25	12.12	39.8
26 Non-metallic mineral products	11,658	1,442	293	2.35	19.00	37.5
27 Basic metals	1,523	702	96	5.06	10.97	29.6
28 Fabricated metal products	16,408	4,378	104	0.49	1.85	11.2
29 Machinery and equipment	9,893	1,424	181	1.33	9.27	83.4
31 Electrical machinery and apparatus	1,060	619	124	8.11	13.89	82.7
32 Communication equipment and apparatus	1,138	567	167	8.70	17.46	33.5
34 Motor vehicles	3,451	758	136	2.38	10.82	31.3
36 Furniture	8,605	2,408	164	1.39	4.98	14.5
Total	114,744	28,187	3,599	2.58	10.49	

Note: The information on aggregate sales of all operating firms is from Industrial Census 2007, National Statistical Office, Thailand

Table 2.4: Firm Distribution in the Main Data Set

Sector	All		Local Firms		FDI Firms		FDI Inflows
	No Firms	Obs	No Firms	Obs	No Firms	Obs	(Million USD)
15 Food	658	2,386	577	1,957	138	429	760.11
17 Textiles	384	1,353	335	1,149	71	204	284.55
18 Wearing apparel	257	1,002	221	819	50	183	69.12
19 Tanning and dressing of leather	104	400	98	354	20	46	39.37
20 Wood and products of wood	79	314	76	304	4	10	51.11
21 Paper and Paper products	120	479	104	399	26	680	252.64
22 Publishing and printing	112	518	102	467	12	51	44.04
24 Chemicals and chemical products	236	927	179	584	98	343	2,479.05
25 Rubber and plastic products	384	1,452	313	1,116	107	336	1,436.77
26 Non-metallic mineral products	293	1,229	274	1,095	44	134	288.21
27 Basic metals	96	362	77	272	27	90	460.60
28 Fabricated metal products	104	399	81	280	35	119	1,446.79
29 Machinery and equipment	181	729	132	483	73	246	2,959.27
31 Electrical machinery and apparatus	124	495	86	319	50	176	220.79
32 Communication equipment and apparatus	167	625	99	240	120	385	7,528.78
34 Motor vehicles	136	420	82	261	62	159	4,524.08
36 Furniture	164	650	120	417	66	233	300.31
Total	3,599	13,740	2,956	10,516	1,003	3,824	23,145.59

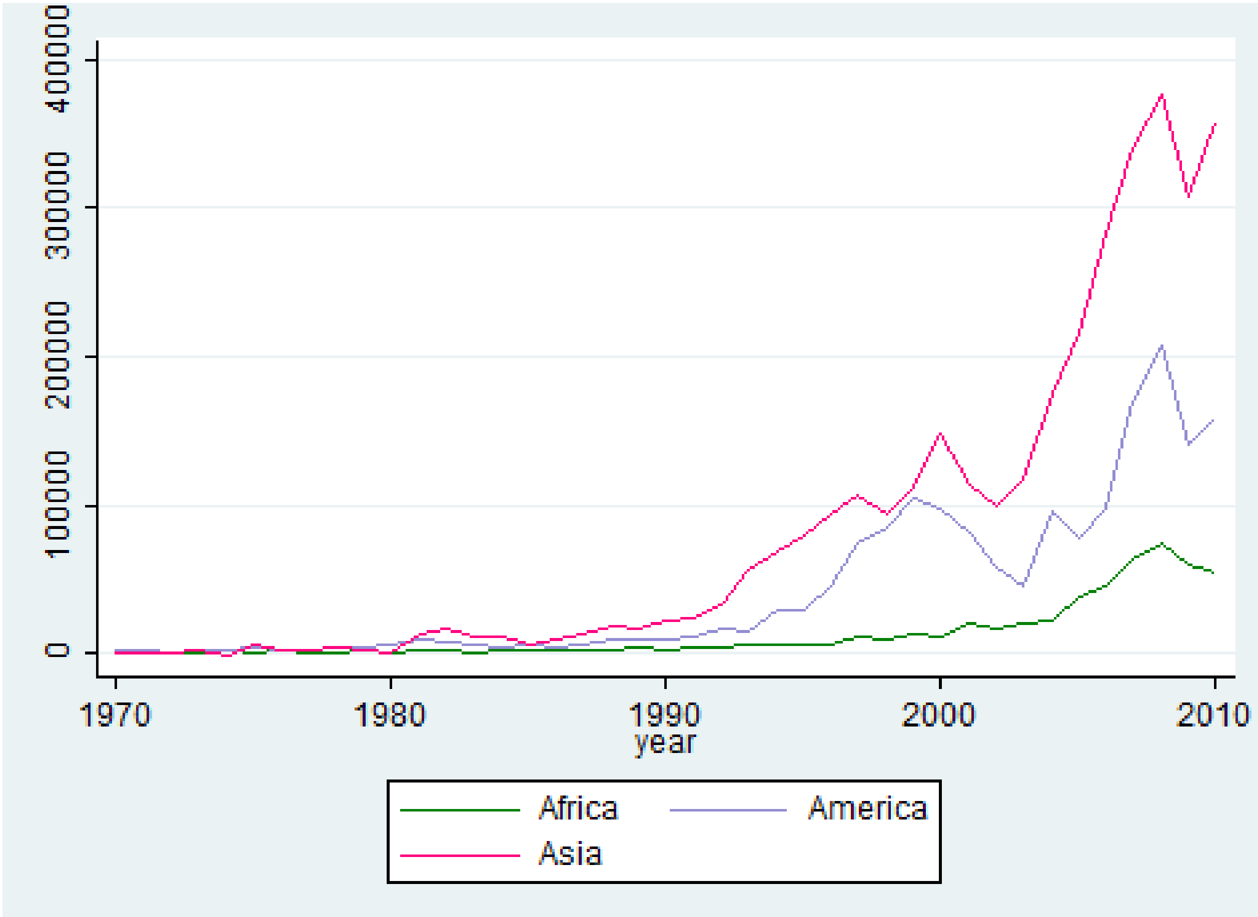
Note: During the sample period, some Thai firms may have received foreign share equity and shifted from one category to the another.

Table 2.5: Number of Firms Categorized by Registered Capital

Sector	Group 1 <1,000,000 (Bahts)	Group 2 1,000,000=< <=100,000,000 (Bahts)	Group 3 100,000,000< (Bahts)
15 Food	93	412	208
17 Textiles	39	273	97
18 Wearing apparel	43	208	30
19 Tanning and dressing of leather	17	75	26
20 Wood and products of wood	6	64	15
21 Paper and Paper products	17	70	47
22 Publishing and printing	29	87	6
24 Chemicals and chemical products	14	155	90
25 Rubber and plastic products	56	282	89
26 Non-metallic mineral products	66	202	59
27 Basic metals	10	56	45
28 Fabricated metal products	19	75	18
29 Machinery and equipment	36	115	47
31 Electrical machinery and apparatus	14	93	30
32 Communication equipment and apparatus	5	84	87
34 Motor vehicles	6	81	63
36 Furniture	19	135	22
Total	489	2,467	979

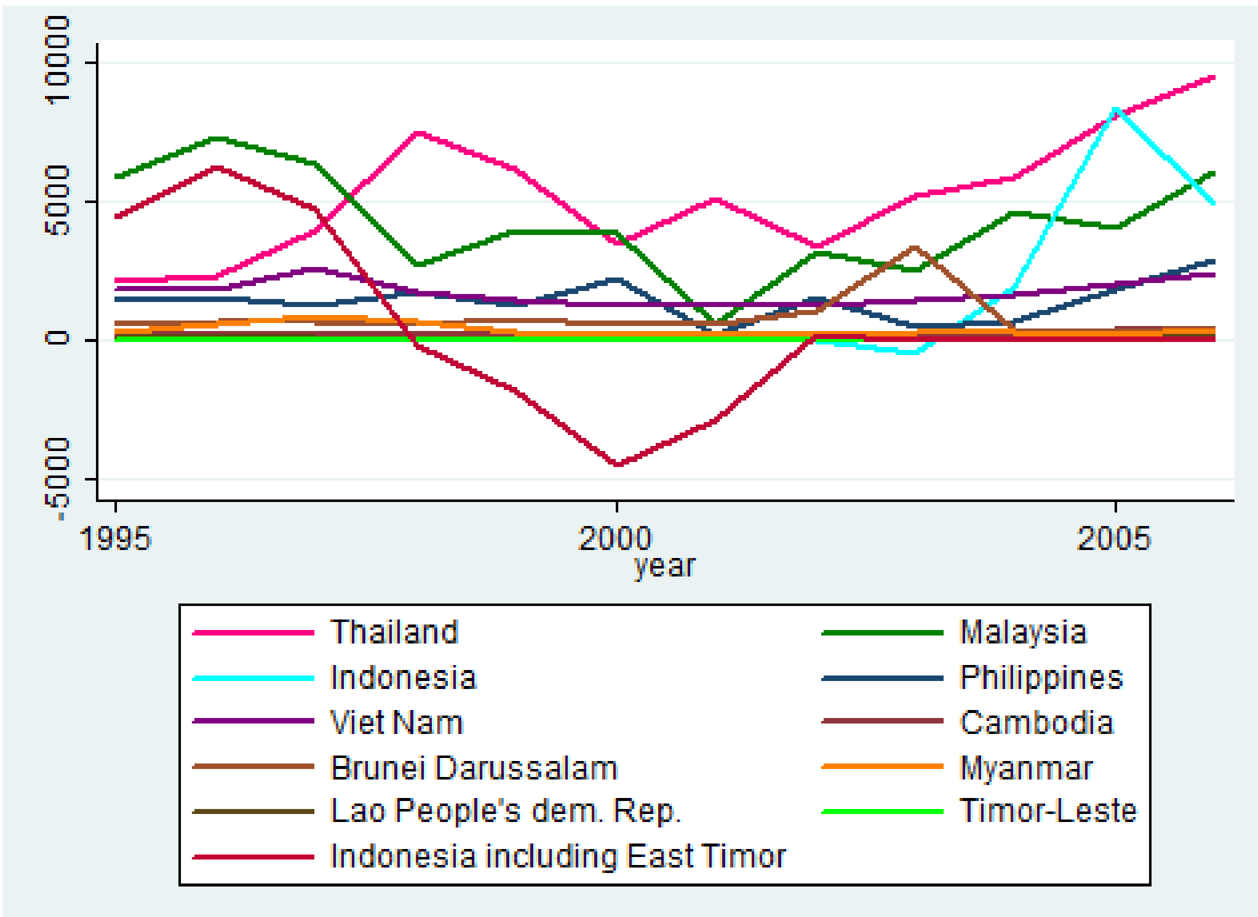
Table 2.6: Variables Used in Production Function

Variables	All Firms				
	Obs	Mean	Std. Dev.	Min	Max
log(value added)	12,505	17.85459	2.039328	9.274918	25.84739
log(quantity)	11,989	13.04003	3.179742	0	23.85105
log(capacity)	12,444	13.71564	3.159516	0.069326	24.63519
log(skilled)	13,253	3.977813	1.589484	0	9.022564
log(unskilled)	9,393	4.078302	1.661862	0	9.725616
log(material)	13,494	17.65296	2.245474	4.448341	23.56016
log(machinery)	13,096	15.61558	3.066329	0	23.4553
log(number of variety)	13,746	0.33082	0.53085	0	5.7301
Variables	Local Firms				
	Obs	Mean	Std. Dev.	Min	Max
log(value added)	9,521	17.48446	1.956936	9.274918	24.97205
log(quantity)	9,235	12.68956	3.123136	-2.503914	23.46921
log(capacity)	9,548	13.36298	3.11147	0.069326	24.63519
log(skilled)	10,120	3.793112	1.575422	0	8.86305
log(unskilled)	7,174	3.868778	1.619606	0	9.46032
log(material)	10,321	17.28527	2.167077	7.72664	23.48208
log(machinery)	9,996	15.13147	3.047564	0	23.3192
log(number of variety)	10,521	0.32524	0.5291024	0	5.7301
Variables	FDI Firms				
	Obs	Mean	Std. Dev.	Min	Max
log(value added)	2,984	19.03553	1.838129	11.13171	25.84739
log(quantity)	2,754	14.21524	3.085041	1.311171	23.85105
log(capacity)	2,896	14.87834	3.035962	2.273209	24.20774
log(skilled)	3,133	4.574418	1.484847	0	9.022564
log(unskilled)	2,219	4.755691	1.615678	0	9.725616
log(material)	3,173	18.84898	2.073258	4.448341	23.56016
log(machinery)	3,100	17.17661	2.565518	0	23.4553
log(number of variety)	3,225	0.3490316	0.536225	0	5.192957



Source: UNCTAD

Figure 2.1: FDI Inflows to Developing Countries from 1970-2010



Source: UNCTAD

Figure 2.2: FDI Inflows to Developing Countries in ASEAN from 1995-2006

Figure 2.3: Map of Thailand

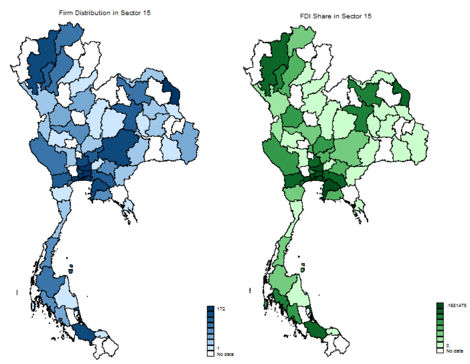


Figure 2.4: Distribution of Firms in Food Sector across Provinces of Thailand in 2006

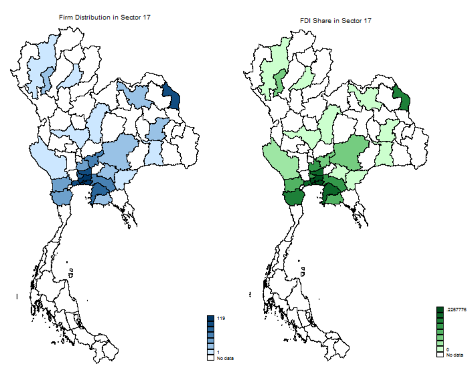


Figure 2.5: Distribution of Firms in Textiles Sector across Provinces of Thailand in 2006

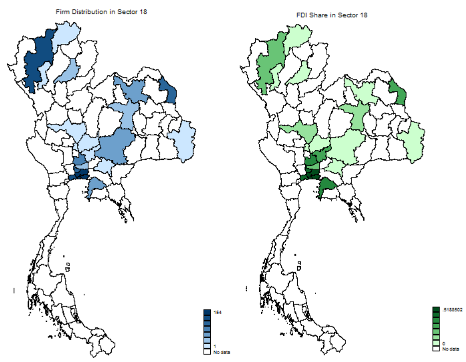


Figure 2.6: Distribution of Firms in Wearing Apparel Sector across Provinces of Thailand in 2006

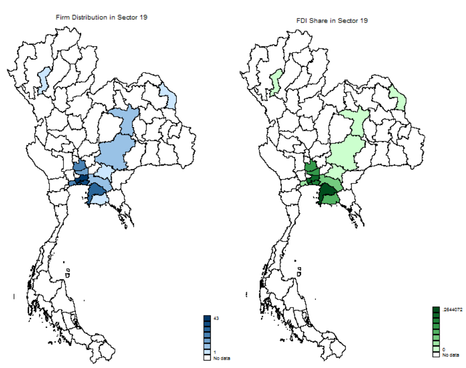


Figure 2.7: Distribution of Firms in Tanning and Dressing of Leather Sector across Provinces of Thailand in 2006

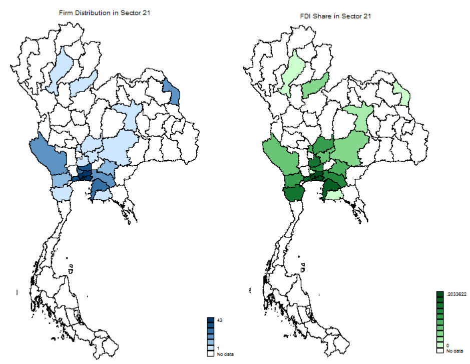


Figure 2.8: Distribution of Firms in Paper and Paper Products Sector across Provinces of Thailand in 2006

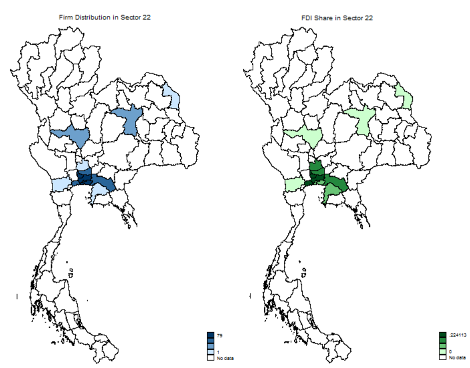


Figure 2.9: Distribution of Firms in Publishing and Printing Sector across Provinces of Thailand in 2006

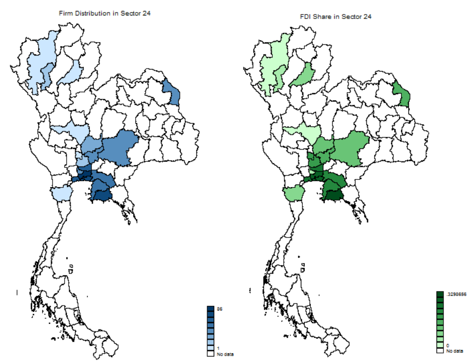


Figure 2.10: Distribution of Firms in Chemicals and Chemical Products Sector across Provinces of Thailand in 2006

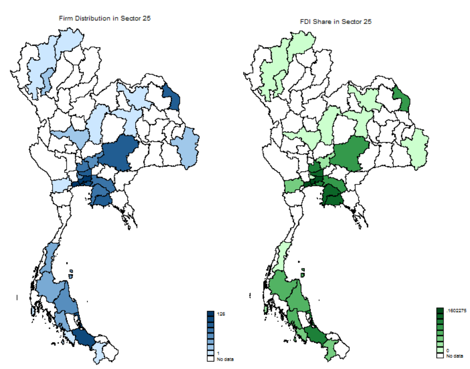


Figure 2.11: Distribution of Firms in Rubber and Plastic Sector across Provinces of Thailand in 2006

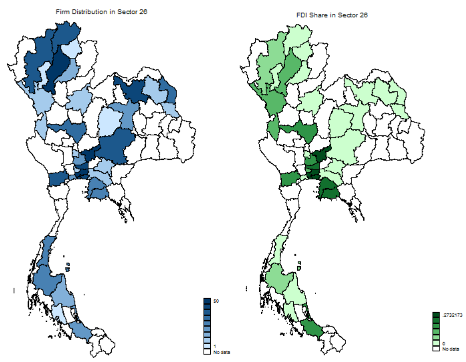


Figure 2.12: Distribution of Firms in Non-Metallic Mineral Products Sector across Provinces of Thailand in 2006

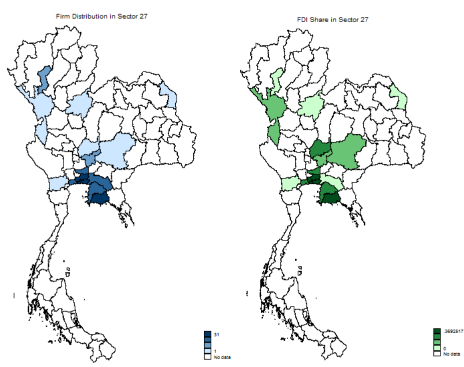


Figure 2.13: Distribution of Firms in Basic Metals Sector across Provinces of Thailand in 2006

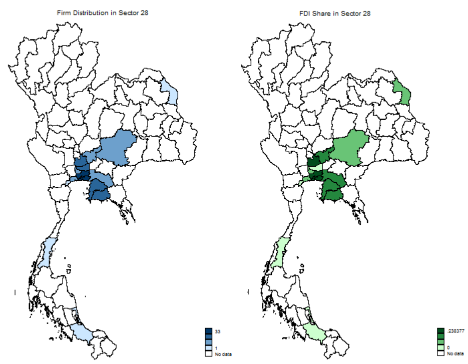


Figure 2.14: Distribution of Firms in Fabricated Metal Products Sector across Provinces of Thailand in 2006

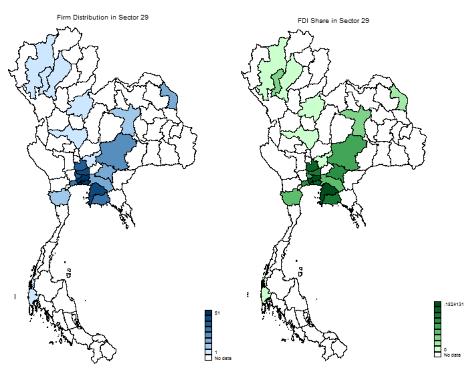


Figure 2.15: Distribution of Firms in Machinery Sector across Provinces of Thailand in 2006

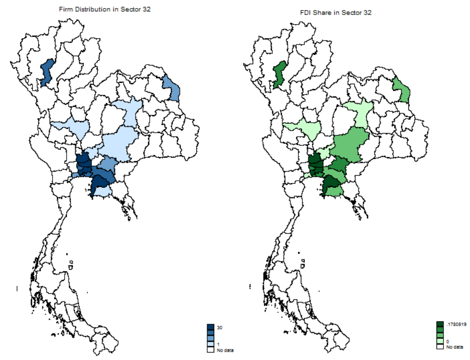


Figure 2.16: Distribution of Firms in Communication Equipment Sector across Provinces of Thailand in 2006

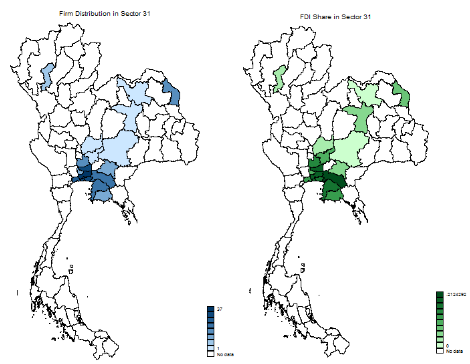


Figure 2.17: Distribution of Firms in Electrical Machinery Sector across Provinces of Thailand in 2006

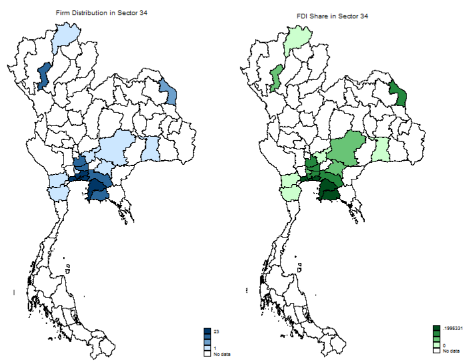


Figure 2.18: Distribution of Firms in Motor Vehicles Sector across Provinces of Thailand in 2006

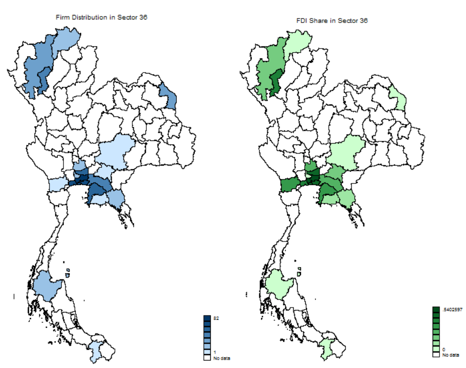


Figure 2.19: Distribution of Firms in Furniture Sector across Provinces of Thailand in 2006

Chapter 3

Total Factor Productivity Estimation

3.1 Introduction

Three problems complicate productivity estimation when employing firm level data. First, firm level productivity is not directly observable and we have to estimate productivity from observable information. The standard approach is to estimate a firm level production function and recover productvitiy from the residuals. Second, even though firm level productivity is unobserved to econometricians, firms know their own productivity level when they hire inputs. Therefore, if firms choose inputs according to their productivity level, then production function estimates that do not account for unobserved productivity are subject to omitted variable bias (Levinsohn and Petrin (2003)). Third, due to data constraints, the literature often estimates productivity using sales or value added information to proxy for outputs. This raises concerns whether productivity estimates reflect a firm's ability to produce output or the firm's ability to charge higher prices.

This chapter combines and modifies the estimation procedures developed by Ackerberg et al. (2006) and De Loecker (2007) to compute firm level productivities. The resulting estimation procedure accounts for a firm's endogenous choice of inputs based on unobserved productivity and allows for multi-product firms.

I apply the estimation procedure to a new dataset that reports highly detailed information for a sample of Thai manufacturing firms during 2001 to 2006. In addition to a wealth of input information, I observe product level physical output information. Therefore, my estimates are robust with respect to the concern that productivity estimates reflect variation in prices instead of physical output. In addition, existing productivity estimation routines assume that firms are in long run equilibrium and produce at capacity. The data reports full capacity physical outputs at product level and thus capacity utilization can be obtained. The capacity utilization allows me to report robustness checks with respect to this assumption.

Ackerberg et al. (2006) estimate firm level production functions accounting for the endogenous relationship between unobserved productivity and firm level inputs and multicollinearity among inputs. Their key identification assumption is that a firm's labor input is relatively rigid and thus cannot be instantaneously adjusted. The contemporaneous term of labor potentially collinear with intermediate input because they can be a function of the same state variables–unobserved productivity and capital. Therefore, the valid instrumental variables for contemporaneous labor are its lagged terms, which are not correlated with material input in the current period.

I impose this assumption only on unskilled labor, because given current labor market conditions in Thailand unskilled labor is relatively rigid but adjustable within the current period. In contrast, skilled labor is very rigid, and the identification assumption is that firms do not adjust skilled labor in the current period in response to productivity shocks. Therefore, skilled labor is predetermined and is not subject to endogeneity concerns. This assumption is reasonable. Skilled labor shortage renders firms less likely to release skilled labor and limits their ability to hire skilled workers. Evidence by World Bank (2008) concludes that firms confront severe skilled labor shortages and experience difficulties to fill vacant positions that require high skilled workers.

Ackerberg et al. (2006) assume that firms produce a single homogeneous product. This assumption is not consistent with the data. To relax this assumption I combine their estimation procedure with De Loecker (2007). In De Loecker (2007) model, firms are producing many product lines but they choose material input levels corresponding to total production. Therefore, he accounts for variation in total firm level output due to firms producing multiple product lines. In addition, he assumes that material input for each product line is proportional to its revenue share in total revenue. Consistent with his approach, I aggregate the product level outputs to the firm level and include product line demand shifters. The results show that the combined model provides significant coefficients of the demand shifters and the returns to scale from the combined model are more reasonable than the estimates from several other models I provide for comparison.

In section 3.2 I provide a brief review of the recent literature concerning productivity estimation. In section 3.3 I develop my own estimation procedure. Section 3.4 explains variable construction and section 3.5 provides the estimation results. The conclusion is given in section

3.6.

3.2 Short Review of Recent Existing Productivity Estimation Routines

The problem of endogeneity embodied in production function and productivity estimation arises because of correlation between unobserved productivity and the optimum input levels. Let t denote time periods and i denote firms. The Cobb-Douglas production function is written as

$$Q_{it} = K_{it}^{\beta_k} L_{it}^{\beta_l} e^{\beta_0 + \omega_{it} + \eta_{it}} \tag{3.1}$$

where Q_{it} is firm output, K_{it} is capital, L_{it} is labor, ω_{it} is unobserved productivity, and η_{it} is an i.i.d disturbance term. The coefficients of capital and labor are denoted by β_k , β_l respectively, and β_0 is the mean productivity. To simplify estimation, the log transformation of equation(3.1) is

$$q_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \eta_{it} \tag{3.2}$$

where q_{it}, k_{it} and l_{it} denote log of output, capital and labor. In many settings output is proxied by deflated sales, y_{it}, and material cost, m_{it}, are introduced as an intermediate input variable. Hence, in practice the production function takes the form

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} \tag{3.3}$$

If the firm level productivity ω_{it} were observed and y_{it} reflects variation in physical output, then the standard classical assumptions apply and ordinary least squares estimates of the β coefficients are consistent. The key identification challenge is that ω_{it} is not observed and firms choose their optimal capital stock, material and labor inputs according to the unobserved level of productivity. Therefore, moving the unobserved level of productivity into the regression disturbance and estimating equation(3.3) via OLS leads to biased and inconsistent estimates of the production function parameters. Several existing estimation approaches solve this identification issues applying various identification assumptions.

The most prevalent approach is proposed by Olley and Pakes (1996). Their identification assumption is that investment is predetermined and positively correlated with productivity but uncorrelated with contemporaneous disturbances. Therefore, investment is a valid instrument. To identify the production function parameters they show that unobserved productivity can be written as a function of investment, capital stock and firm age. The investment and firm age work as instrumental variables to correct for endogeneity in unobserved productivity. Olley and Pakes (1996) approximate the productivity with a third order polynomial and substitute this function into equation(3.3) to estimate β_l and β_m consistently. In a second step, similar to the approach explained below, they nonparametrically estimate the coefficients of capital and firm age to back out productivities. The challenge with this approach is that investment values need to be positive, but changes in investment take a long time and therefore investment is often reported as zero or negative in most firm-level datasets.

To cope with this problem, Levinsohn and Petrin (2003) developed an alternative strategy that relies on intermediate inputs rather than investment. The main advantage is that intermediate inputs are usually observed and they are positive. Levinsohn and Petrin (2003) assume that firms hire an optimal amount of materials taking their productivity and capital stock as given. Furthermore, productivity is positively correlated with the inputs. Then, the demand for material inputs can be written as $m_{it} = f_t(\omega_{it}, k_{it})$. Assuming monotonicity, the material demand function can be inverted to the unobserved productivity as $\omega_{it} = f_t^{-1}(m_{it}, k_{it})$. Substituting this expression into the production function equation(3.3) results in

$$y_{it} = \beta_l l_{it} + \phi_{it}(m_{it}, k_{it}) \tag{3.4}$$

where

$$\phi_{it}(m_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \beta_m m_{it} + \omega_{it}(m_{it}, k_{it}) + \eta_{it} \tag{3.5}$$

Because the functional form of $\phi_{it}(m_{it}, k_{it})$ is not known, we cannot estimate equation(3.4). To solve this problem Levinsohn and Petrin implement a semiparametric approach and let the relationship between the unobserved productivity ω_{it} and all inputs follow a low order polynomial. For example, if the productivity is a third order polynomial of three inputs, then the production function is

$$y_{it} = \delta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \sum_{h=0}^{3} \sum_{j=0}^{3-h} \delta_{hj} k_{it}^h m_{it}^j + \eta_{it}. \tag{3.6}$$

With this specification at hand, the first step of the estimation routine requires that we estimate the β_l via ordinary least squares. Ackerberg et al. (2006) point out that estimation of (3.6), theoretically, suffers from multicollinearity. The problem is that both labor and material inputs are determined by the same set of state variables: unobserved productivity and the capital stock. They show that in this case the impacts of labor and material on output are not separately identified.

Ackerberg et al. (2006) introduce a new identification assumption to solve this problem. The source of the multicollinearity problem is that both labor and materials simultaneously adjust to productivity and capital. To break this simultaneous adjustment process, Ackerberg et al. (2006) point out that labor does not immediately adjust, but requires some time to arrive at the new equilibrium level. For example, firms may take a few months to train workers before placing them on production sites. Consequently, the optimum level of labor is chosen at time $t-b$ where b is a fraction of time unit, $0 < b < 1$. Thus material will be chosen after the realizations of capital and labor. For this reason, material demand is a function of productivity, labor and capital. With this assumption, labor inputs are not collinear with material in the same time period.

All three approaches–Olley and Pakes (1996), Levinsohn and Petrin (2003) and Ackerberg et al. (2006)–assume a homogeneous product within each sector, and firms are only different in productivity even though the current market structure may follow monopolistic competition rather than perfect competition. This implies that different firms produce different varieties of products and firms may be active in multiple product lines. De Loecker (2007) extends Olley and Pakes (1996) to account for multi-product firms. Thus, the impact of demand variations on firm level outputs differ depending on the product lines firms produce. These variations are captured by demand shifters of the product lines in each industry, which is a weighted average market share of firms in each product line.

Most productivity estimation routines use revenues or value added as measure of output due to the fact that physical output is usually not reported in firm level dataset. However, revenue based productivity may not represent true technological efficiency. Foster et al. (2008) point out that considering only revenue based productivity as a measure of technological efficiency may overlook the role of price variations; a change in productivity can be driven by either output price changes or improvement in technology. They provide evidence that the relationship between output prices and quantity productivity is negative, while it is positive for revenue productivity.

To summarize, I improve upon these existing estimation techniques in several ways. First, I collect data on physical output as well as firm level revenues. Therefore we can examine the differences in production function estimates based on both measures of output. Second, using data on capacity utilization I examine robustness with respect to the assumption that firms are in long run equilibrium and produce at full capacity. Third, by combining the estimation procedure of Ackerberg et al. (2006) and De Loecker (2007) we account for multi-product firms without running into the issue of zero investment levels as in Olley and Pakes (1996) and the multicollinearity issue of Levinsohn and Petrin (2003).

3.3 Empirical Productivity Estimation Procedure

In this section I augment the basic production function to account for multi-product firms. Next I lay out an estimation procedure based on Ackerberg et al. (2006). The basic idea of this procedure is that unobserved productivity can be instrumented by fundamental inputs.[11]

Following De Loecker (2007), I compute industry level demand shifters to account for multi-product firms as a ratio of weighted average sales of a product line s to the price index of the industry. Let ms_{ist} be the market share of firm i in product s and let R_{ist} be the firm's revenue realized from the sales of product s. The demand shifter in industry I is defined as

$$D_{Ist} \equiv \frac{\sum_i^{N_s} ms_{ist} R_{ist}}{P_{st}}, \tag{3.7}$$

where N_s is the number of active firms selling product s and P_{st} is the average price of product s. According to De Loecker (2007), D_{Ist} represents an aggregate demand shock for product s in period t. To translate this aggregate demand shock to the firm's output response, assume that an aggregate demand shock impacts the firm's output of product s proportionately to the firm's output share in product s. To be precise, let $share_{ist} \equiv \frac{sales_{ist}}{sales_{it}}$ be the share of firm i's total sales realized in product s. The demand shifter for firm i is then defined as $shq_{it} \equiv ln(share_{ist} D_{st})$.

Let num_{it} be the number of product lines the firm produces in period t. The augmented production function is then

$$y_{it} = \beta_0 + \beta_s s_{it} + \beta_u u_{it} + \beta_k k_{it} + \beta_{num} num_{it} + \sum_{s=1}^{num_{it}} \beta_{shq} shq_{ist} + \omega_{it} + \eta_{it} \tag{3.8}$$

where y_{it} is output. s_{it} and u_{it} denote skilled and unskilled labor respectively.[12] k_{it} represents capital stock. The unobserved part consists of ω_{it} and η_{it} which are productivity and the i.i.d disturbance term. The productivity, ω_{it}, is a state variable known to firms and correlated with input choices, but the disturbance, η_{it}, is not. The goal is to estimate the firm's productivity ω_{it}. The estimation of the production function parameters follows two stages.

[11] I use Petrin et al. (2004) procedure as the base routine and modify their program as the routine explained in this chapter.

[12] This is a small extension compared to Ackerberg, Caves and Frazer who do not distinguish between different types of skill levels.

Stage I

Following Levinsohn and Petrin (2003) and Ackerberg et al. (2006), optimal material inputs are determined by the productivity and the fundamental inputs and are a valid instrument for unobserved productivity.[13] Thus, demand for material is $m_{it} = f_t(\omega_{it}, s_{it}, u_{it}, k_{it})$. Assuming monotonicity, the material demand function can be inverted to the unobserved productivity as $\omega_{it} = f_t^{-1}(\text{s}_{it}, u_{it}, k_{it})$. Substituting productivity into equation (3.8), the production function becomes

$$y_{it} = \beta_{num} num_{it} + \sum_{s=1}^{num} \beta_{shq} shq_{ist} + \phi_t(s_{it}, u_{it}, k_{it}) + \eta_{it} \tag{3.9}$$

where the endogenous part is

$$\phi_{it}(s, u_{it}, k_{it}) = \beta_0 + \beta_s s_{it} + \beta_u u_{it} + \beta_k k_{it} + f_t^{-1}(s_{it}, u_{it}, k_{it}). \tag{3.10}$$

The coefficients of fundamental inputs cannot be estimated with linear regression in equation (3.9) because of the correlation between input choices and unobserved productivity. Thus some further assumptions are needed to specify unbiased input estimators in the second stage. As the functional form for the relationship between inputs and productivity is unknown I assume a low order polynomial function. I try second to fourth order, and select the order that gives most significant coefficients of inputs in the second stage. Hence, equation (3.10) becomes

$$\phi_{it} = (s_{it}, u_{it}, k_{it}) = \delta_0 + \sum_{d=1}^{Dg} pol_d(s_{it}, u_{it}, k_{it}) \tag{3.11}$$

where $Dg = 2, 3, 4$ and pol_d is polynomial set of degree d. Let firms choose product lines regarding their market demand; thus num_{it} and shq_{ist} are exogenous. I substitute equation (3.11) in equation

[13] See proof in Levinsohn and Petrin (2003)

(3.9) and obtain $\widehat{y}_{it}$, $\widehat{\beta}_{num}$ and all $\widehat{\beta}_{shq}$. Then I compute

$$\widehat{\phi}_{it} = \hat{y}_{it} - \hat{\beta}_{num} num_{it} - \sum_{s=1}^{num} \hat{\beta}_{shq} shq_{ist}. \tag{3.12}$$

Stage II

In this stage we estimate the remaining input coefficients. Assume that unobserved productivity evolves following a first order Markov process:

$$\omega_{it} = E[\omega_{it}|I_{it-1}] + \xi_{it} = E[\omega_{it}|\omega_{it-1}] + \xi_{it} \tag{3.13}$$

The intuition for this assumption is that firms form beliefs about their current period productivity based on the previous period productivity. Apply a second order polynomial of ω_{it-1} in equation (3.13) such that $\omega_{it} = \alpha_0 + \alpha_1 \omega_{it-1} + \omega_{it-1}^2 + \xi_{it}$.

The shock to productivity can be obtained as $\xi_{it} = \omega_{it} - \hat{\omega}_{it}$. And $\widehat{\phi}_{it}$ can be written from equations (3.12) and (3.13) as

$$\widehat{\phi}_{it} = \beta_s s_{it} + \beta_u u_{it} + \beta_k k_{it} + [\alpha_0 + \alpha_1 \omega_{it-1} + \alpha_2 \omega_{it-1}^2] + \xi_{it} \tag{3.14}$$

and therefore the residual of productivity is

$$\widehat{\xi}_{it} = \widehat{\phi}_{it} - (\beta_s s_{it} + \beta_u u_{it} + \beta_k k_{it} + [\alpha_0 + \alpha_1 \omega_{it-1} + \alpha_2 \omega_{it-1}^2]). \tag{3.15}$$

Following Levinsohn and Patrin (2003) and Ackerberg et al. (2008), I interact instrumental variables with the residuals of productivity, $\widehat{\xi}_{it}$, then nonparametrically obtain estimators of instrumental variables that minimize the product of $\widehat{\xi}_{it}$ and the instrument. Capital and skilled labor are assumed to be predetermined and hence they are not correlated with productivity shock in the same period which makes them valid instruments. The moment conditions that validate contemporaneous terms of capital stock and skilled labor as instruments are

$$E\left[\xi_{it} \cdot \begin{pmatrix} k_{it} \\ s_{it} \end{pmatrix}\right] = 0. \tag{3.16}$$

Next I modify the identification assumption adopted by Ackerberg et al. (2006). They assume rigid labor markets and therefore all labor inputs are adjusted with a time lag. I modify this assumption to match the Thai labor market. According to World Bank (2008), Thailand has a shortage of skilled labor since 2004 especially in major sectors such as garments, wood and furniture, machinery, and auto-parts sectors. This implies that it is very costly to adjust skilled labor inputs to contemporaneous shocks and I therefore assume that skilled labor inputs are predetermined and are not correlated with contemporaneous shocks. However, Thailand does not suffer from an unskilled labor shortage. Following Ackerberg et al. (2006) I assume that unskilled labor is more flexible than skilled labor, but does not adjust immediately. Instead, unskilled labor adjusts to shocks within one production period, which is simultaneously determined by the same variables as material input, and causes multicollinearity. However, the lag term of unskilled labor and material inputs are not simulataneously determined by the same contemporeneous shock and capital stock. Therefore this identification assumption breaks the multicollinearity of the labor and material inputs. This identification assumption delivers the last moment condition

$$E[\xi_{it} \cdot u_{it-1}] = 0. \tag{3.17}$$

Under the identification assumptions, equations (3.16) and (3.17) are valid moment conditions that we take to the data. Similar to Levinsohn and Petrin (2003), the theoretical expectations imply that we minimize the sample analogue

$$\sum_h \left\{ \frac{1}{T} \cdot \frac{1}{N} \sum_{t=1}^{T} \sum_{i=1}^{N} \widehat{\xi}_{it}(\beta_k, \beta_s, \beta_u) \times \begin{bmatrix} k_{it} \\ s_{it} \\ u_{it-1} \end{bmatrix} \right\}^2 \tag{3.18}$$

with respect to the parameters β_k, β_s,and β_u to obtain coefficient estimates.

To operationalize this estimation procedure I choose starting values for the input elasticities. With these starting values at hand I estimate the $\hat{\alpha}$ paramters in equation (3.14) by linear regression. The residual of this specification is $\hat{\hat{\xi}}_{it}$. With $\hat{\hat{\xi}}_{it}$ at hand I compute the sample analogue of (3.18). The estimation procedure iterates over different values for the input elasticities until (3.18) is minimized.

With the coefficient estimates at hand, we recover the productivity estimates from the difference

$$\widehat{\omega}_{it} = \widehat{y}_{it} - \widehat{\beta}_{num} num_{it} - \sum_{s=1}^{num} \widehat{\beta}_{shq} shq_{ist} - \beta_k^* k_{it} - \beta_s^* s_{it} - \beta_u^* u_{it} \tag{3.19}$$

Applying this procedure I estimate productivity with three types of outputs (value-added, physical outputs and full capacity physical outputs) for 17 sectors. In addition I estimate several existing procedures from the literature for comparison.

3.4 Variables

The main dataset is an unbalanced firm level dataset from the annual survey of manufacturing sectors of Thailand during 2000 - 2006[14]. This dataset provides quantity and capacity as well as revenue of each product variety by firm. The dataset contains 3,599 firms providing 13,740 observations after cleaning. The details are in Table 2.4 of chapter 2. Seventeen sectors are included in

[14]See details in chapter.

the estimation.

In this chapter, only production variables are employed. Production input variables consist of skilled and unskilled labor, machinery value and material costs. s_{it} denotes skilled labor variable and is defined as man-year workers with high-school degrees or above. u_{it} denotes unskilled labor variables and is defined as man-year workers with education lower than high school. The capital stock, k_{it}, denotes deflated value of machinery and equipment of firm i at time t. The deflator is the producer price index by industry and year.

For one variation of the productivity estimates we employ the firms full capacity as measure of output. The difficulty is that when firms do not produce at full capacity, then they do not likely hire the amount of inputs they would have employed at full capacity. Therefore I adjust the variable inputs by the firms capacity utilization. Let $capu_{it}$ denote a firm i's capacity utilization in period t. We define skilled and unskilled labor inputs as well as material inputs at full capacity by $sc_{it=\frac{s_{it}}{capu_{it}}}$, $uc_{it=\frac{u_{it}}{capu_{it}}}$, and $mc_{it} = \frac{m_{it}}{capu_{it}}$.

Finally, to estimate a production function I need a measure of output. I work with three types of output measures, a value added measure, a physical production based measure and a capacity measure.

To compute value added we need to correct the firm's revenues by the contribution of the intermediate inputs. In this particular case this means that I correct the firm's total sales by the contribution of the material inputs. Following Levinsohn and Petrin (2000), I compute the contribution of the intermediate input as the revenue share of the intermediate input times the level of the intermediate input. Value added is then defined as the total sales of firm i net of the contribution of the intermediate input.[15]

To compute the output measure based on physical output I first compute a measure of intermediate inputs based on physical quantities. Since material costs for each product line is unobservable

[15] Several ways exist in the literature to compute the contribution of the intermediate input. An alternative to measure employed here is to compute the log difference between the sales and the log level of the intermediate input times the intermediate input's revenue share. I leave these alternative methods to future research.

but the product price of each product line is computable, the material costs in terms of quantity for each product line can be recovered. I weigh material costs with the quantity share of each product line and then divide it by the price of each product line.

$$mq_{sit} = \frac{m_{it} \times share_{sit}}{p_{sit}} \tag{3.20}$$

where mq_{sit} denotes material in terms of quantity that firm i uses to produce product line s, m_{it} is material costs, $share_{sit}$ is the share of quantity of product line s to total quantity of firm i and p_{sit} is price of product line s. Then I aggregate mq_{sit} for firm i to get its total material quantity.

Similar as in the value added measure I now purge the contribution of the intermediate input from the physical quantity the firm produces. To do that I compute the contribution of the intermediate input as the share of the physical intermediate input measure in the total quantity and multiply this share by the level of intermediate inputs. The quantity measure employed in the estimation is the physical output of the firm net of the contribution of the intermediate input.

To obtain the output measure based on the firm's capacity I employ the same strategy as for the firm's physical output. The difference is that I use the firm's reported full employment capacity instead of the actual level of output produced and use the adjusted material quantity at full capacity.

3.5 Results

I focus my discussion on the productivity estimates of three sectors: food, communication equipment and motor vehicles.[16] The results for other sectors are reported in Table 3.2 to Table 3.8.

For each sector, I report 12 sets of estimated production function coefficients. They vary by the estimation routine as developed and explained above and the measurments of outputs. Table 3.1 separates the results in three panels according to the definition of output. In addition, I break

[16] The food sector represents the largest production sector in Thailand with 16% of manufacturing GDP according to the Office of National Economic and Social Development Board. The other two sectors took the largest shares of FDI inflows during the sample period.

down the results for each measure of output by 4 estimation routines. Levinsohn and Petrin (LP), LP adjusted with demand shifter according to De Loecker (LPDL), Ackerberg Caves and Frazer (ACF) and ACF adjusted for demand shifters according to De Loecker (ACFDL). For each sector, I report the the production function coefficients, the impact of the number of product lines on output and an estimate of the returns to scale.

Across the three industries that I consider, several patterns are striking. First, comparing the LP estimates to the LPDL estimates the results show that demand shifters have almost no impact on the input elasticities. However, comparing the ACF estimates to the ACFDL estimates, the results show that accounting for demand shifters makes a big difference. The estimated input elasticities based on the ACFDL estimates tend to be larger than the elasticities from the ACF estimates. In addition, many of the coefficient estimates on the demand shifters have a statistically significant impact on output. For details see Table 3.2 in the appendix.

Furthermore across the various estimation routines I find that the input elasticities on unskilled labor are substantially larger in ACFDL compared to the other estimation routines. One advantage of Thailand as a production location is cheap unskilled labor and limited labor market regulations that make it easy for firms to adjust unskilled labor input. Therefore we would expect that unskilled labor coefficients should be highly significant. The results suggest that unskilled labor intensive technology is still prevalent in Thailand although policies promoting advance technology have been implemented for decades. Therefore the analysis below is based on the results from ACFDL model.

3.5.1 Food and Beverage Sector

The results of production function estimates for food sector are shown in the first section of Table 3.1. Focusing on the ACFDL estimates the production function estimates of the food sector exhibit increasing returns to scale and unskilled labor intensive technology for all types of outputs.

The unskilled labor coefficients for all output types are larger than the coefficients of skilled labor and machinery. This implies that producers in food sector rely heavily on unskilled labor in production. All demand shifters in the food sector are significant for all types of outputs despite negative coefficients of number of product lines. This suggests that firms that produce more product lines are less productive, but an increase in demand raises total output. The firms gain from economies of scales but producing more product lines incuring extra cost for each product line.

When comparing production function coefficients for value added and quantity outputs, the coefficients of skilled labor and machinery for quantity are bigger than those for value added. In contrast, coefficient of unskilled labor for quantity is smaller than that of value added. However all input coefficients for full capacity output are similar to those for value added.

3.5.2 Radio, Television, and Communication Equipment Sector

Unlike food sector, the returns to scale estimates of this sector are not consistent across output types. The results demonstrate increasing returns to scale for value added and decreasing returns to scale for quantity and full capacity. In addition, the demand shifter coefficients are insignificant for value added but significant for quantity and full capacity. This evidence reflects the role of output price variations in productivity estimates. Even though the demand shifters suggest a positive shock to physical output, in terms of valued added this effect is dampened by lower prices.

In the value added driven estimates skilled labor has a positive and significant impact on output. In the physical output based estimates the impact of skilled labor is negative or nonexistent. This suggests that an increase in skilled labor produces additional value, but unskilled labor drives the total physical output of production.

Across all estimation routines for this sector, the coefficient estimates are less consistent across different output types compared to the estimates in the food sector. This suggests that the estimation routines and deifinition of outputs may have a significant impact on productivity estimates. Compared to the food industry one identification issue in this industry is that output is concentrated among fewer firms which limits the identifying variation.

3.5.3 Motor Vehicle, Trailer and Semi-Trailer Sector

Similar to food sector, the results for all types of outputs of this sector exhibit increasing returns to scale, but all demand shifter coefficients are significant only for value added output. The results can be interpreted that firms in this sector rely on unskilled labor, machinery and variety of product lines to increase value added while their production process needs highly educated workers to increase quantity.

Three conclusions can be drawn from the production function coefficients of the motor vehicle sector. First, the wide range of product lines is important to create value added for the firms. Secondly, skilled workers play a crucial role to increase production. A higher value of machinery increases value added, but do not increase physical output.

3.5.4 Productivity Estimates

After estimating production functions, I recover productivity estimates for each sector using three output types with four different models. I focus only the productivity estimates obtained from ACFDL model because the endogeneity and multicollinearity problems are corrected when allowing for multiple product firms. In order to see the difference between the LP model, and the ACFDL model, I compare the distributions of productivity estimates for the three major sectors discussed above in Figures 3.1, 3.2 and 3.3.[17]

Figure 3.1 illustrates the productivity distributions of food sector. Figure 3.2 shows the productivity distributions of communication equipment sector. And Figure 3.3 presents the productivity distributions of motor vehicle sector. The first row of each graph depicts the distributions of log of value added productivity estimates from Ackerberg et al. (2006) with De Loecker (2007) extension (lnacfdlv2) and the distribution of log of value added productivity estimates from Levinsohn and Petrin (2003) (lnlpv2). Analogously, the middle row of each graph represents the distributions of

[17] The analysis for the pooled productivity estimates is in the appendix.

log quantity productivity estimates from Ackerberg et al. (2006) with De Loecker (2007) extension (lnacfdlq2), the distribution of log of quantity productivity estimates from Levinsohn and Petrin (2003) (lnlpq2). And the bottom row of each graph represents the distributions of capacity productivity estimates from Ackerberg et al. (2006) with De Loecker (2007) extension (lnacfdlq3), and the distribution of log of capacity productivity estimates from Levinsohn and Petrin (2003) (lnlpq3).

The productivity estimates from LP are larger than the estimates from ACFDL for all types of outputs. This evidence reflects the importance of multi-product firm characteristics and correction of multicollinearity. Without allowing for heterogeneity across firms within sectors, the productivity estimates seem overestimated.

3.6 Conclusion

The endogeneity problem embodied in traditional productivity estimation has been a controversial issue in empirical studies. Many available approaches were proposed to alleviate this problem under different circumstances. I combine two available approaches, Ackerberg et al. (2006) and De Loecker (2007), to estimate productivity that is corrected for endogeneity and multicollinearity when allowing for multiple product firms. The estimation in this chapter employs firm-level data from manufacturing sectors in Thailand during 2001-2006.

The estimation strategy in this chapter corrects for endogeneity and multicollinearity under monopolistic competition which conforms with the actual market situation. The special feature of this dataset is that it provides quantity and capacity output levels along with revenue for each product lines, thus I am able to estimate productivity in terms of three types of outputs: value added, quantity and full capacity levels. The estimation procedure matches Thai labor market conditions where the skilled labor shortage problem results in a rigid labor market for skilled workers.

The results reflect the importance of the multi-product firm features. The coefficients of demand shifters are significant in most sectors. The returns to scale estimates from the extension of Ackerberg et al. (2006) (ACFDL) are more reasonable than the estimates from other models. The results indicate that increasing returns to scale are present in almost all manufacturing sectors in Thailand.

The production function estimates of three major sectors: food, communication equipment, and motor vehicle, reflect that the current production technology still relies on unskilled labor which is one of Thailand's advantages. In addition, the productivity estimates from ACFDL have lower values than those from LP. This evidence indicates the importance of multi-product firm features. Without relaxing homogeneous output assumption, the productivity estimates are overestimated.

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Table 3.1: Production Function Results of Three Major Sectors

Food Products and Beverages (ISIC 15)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.242***	0.238***	0.210	0.293***	0.047*	0.058***	0.055	0.370***	0.098***	0.109***	0.004	0.247***
	(0.030)	(0.021)	(0.255)	(0.067)	(0.028)	(0.019)	(0.189)	(0.130)	(0.027)	(0.019)	(0.237)	(0.173)
Unskilled	0.213***	0.243***	0.324	0.856***	0.054**	0.086***	0.000	0.480***	0.033	0.072***	0.001	0.840***
	(0.027)	(0.019)	(0.268)	(0.145)	(0.024)	(0.019)	(0.234)	(0.187)	(0.023)	(0.019)	(0.235)	(0.283)
Machinery	0.163***	0.098	0.000	0.125**	0.199**	0.000	0.055	0.290***	0.102**	0.172	0.005	0.195**
	(0.064)	(0.174)	(0.037)	(0.051)	(0.096)	(0.153)	(0.203)	(0.075)	(0.045)	(0.130)	(0.233)	(0.091)
No. of		-0.089***		-0.089***		-0.268***		-0.281***		-0.278***		-0.291***
Product Lines		(0.034)		(0.033)		(0.036)		(0.036)		(0.037)		(0.037)
Returns to Scale	0.618	0.579	0.535	1.273	0.301	0.143	0.110	1.141	0.233	0.353	0.010	1.283

Radio, Television and Communication Equipment and Apparatus (ISIC 32)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.237***	0.253***	0.577	0.499**	-0.253***	-0.226***	0.001	0.059	-0.137*	-0.124**	0.001	0.026
	(0.076)	(0.050)	(0.360)	(0.198)	(0.075)	(0.062)	(0.259)	(0.335)	(0.072)	(0.049)	(0.238)	(0.316)
Unskilled	0.214**	0.222***	0.285	0.626**	-0.119	-0.136**	0.001	0.881**	0.022	-0.002	0.001	0.705*
	(0.064)	(0.043)	(0.188)	(0.266)	(0.077)	(0.060)	(0.272)	(0.414)	(0.065)	(0.050)	(0.318)	(0.376)
Machinery	-0.070	0.000	0.000	0.024	-0.001	0.632**	0.000	0.051	-0.068	0.046	0.001	0.014
	(0.058)	(0.202)	(0.070)	(0.043)	(0.111)	(0.321)	(0.231)	(0.180)	(0.072)	(0.245)	(0.231)	(0.179)
No. of		-0.175**		-0.109		0.113		0.024		-0.028		-0.020
Product Lines		(0.086)		(0.096)		(0.131)		(0.134)		(0.107)		(0.107)
Returns to Scale	0.381	0.475	0.863	1.149	-0.373	0.270	0.001	0.990	-0.183	-0.080	0.003	0.746

Motor Vehicles, Trailers and Semi-Trailers (ISIC 34)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.131**	0.133***	0.000	0.123	0.018	-0.007	0.003	0.840**	0.036	0.009	0.000	0.375
	(0.055)	(0.043)	(0.210)	(0.218)	(0.060)	(0.050)	(0.269)	(0.393)	(0.068)	(0.046)	(0.240)	(0.304)
Unskilled	0.124***	0.117**	0.000	0.789***	0.081	0.032	0.004	0.257	0.110	0.065	0.054	0.689**
	(0.046)	(0.046)	(0.263)	(0.325)	(0.059)	(0.060)	(0.322)	(0.416)	(0.072)	(0.057)	(0.275)	(0.317)
Machinery	0.185	0.071	0.000	0.293**	-0.255	0.880**	0.000	0.140	-0.077	0.547	0.000	0.096
	(0.143)	(0.216)	(0.045)	(0.133)	(0.276)	(0.379)	(0.231)	(0.287)	(0.115)	(0.381)	(0.227)	(0.249)
No. of		0.054		0.055		-0.391***		-0.512***		-0.548***		-0.460***
Product Lines		(0.069)		(0.078)		(0.102)		(0.119)		(0.096)		(0.123)
Returns to Scale	0.441	0.321	0.000	1.204	-0.156	0.905	0.007	1.237	0.068	0.622	0.054	1.161

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

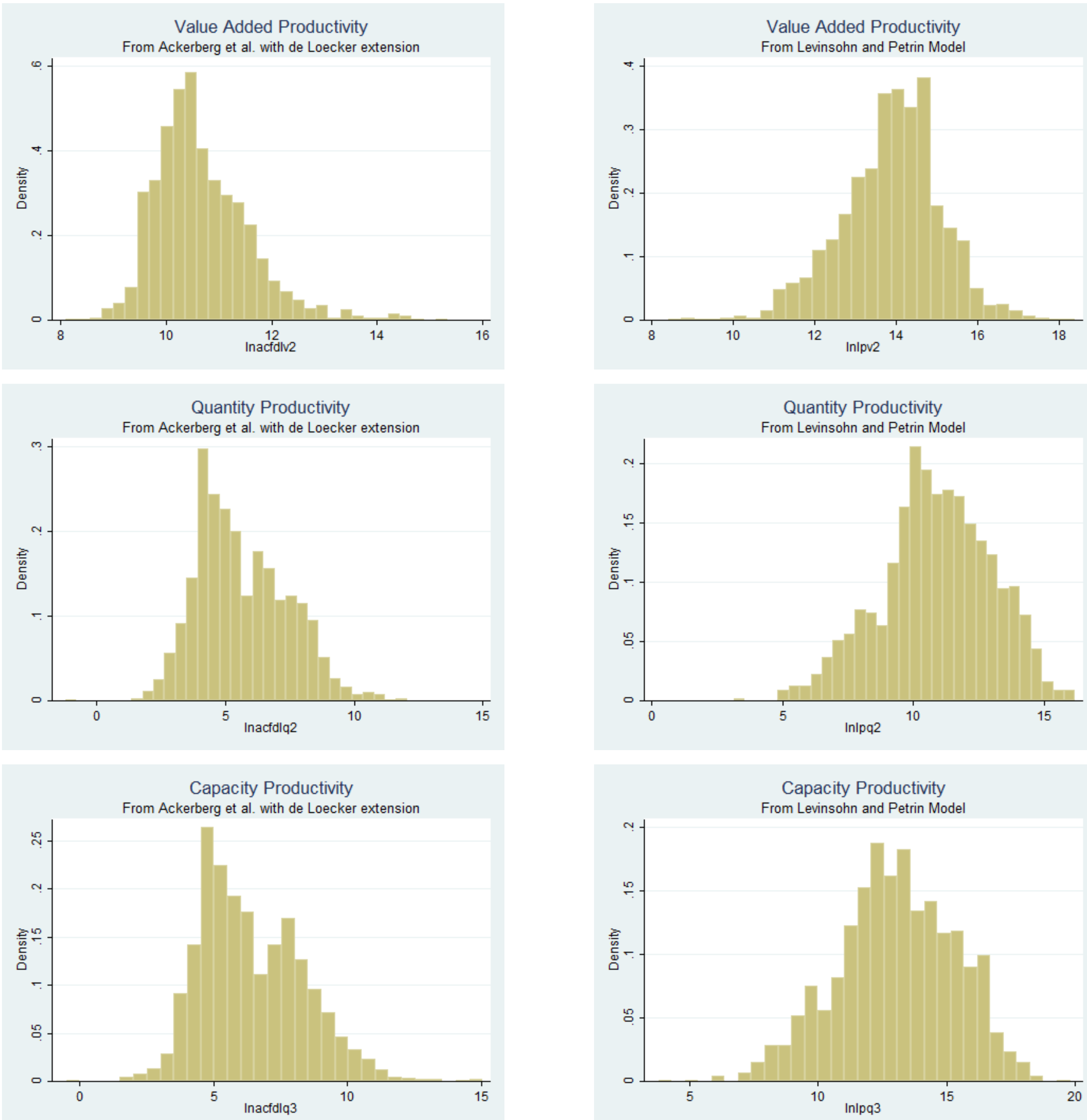

Figure 3.1: Productivity Estimates of Food Sector

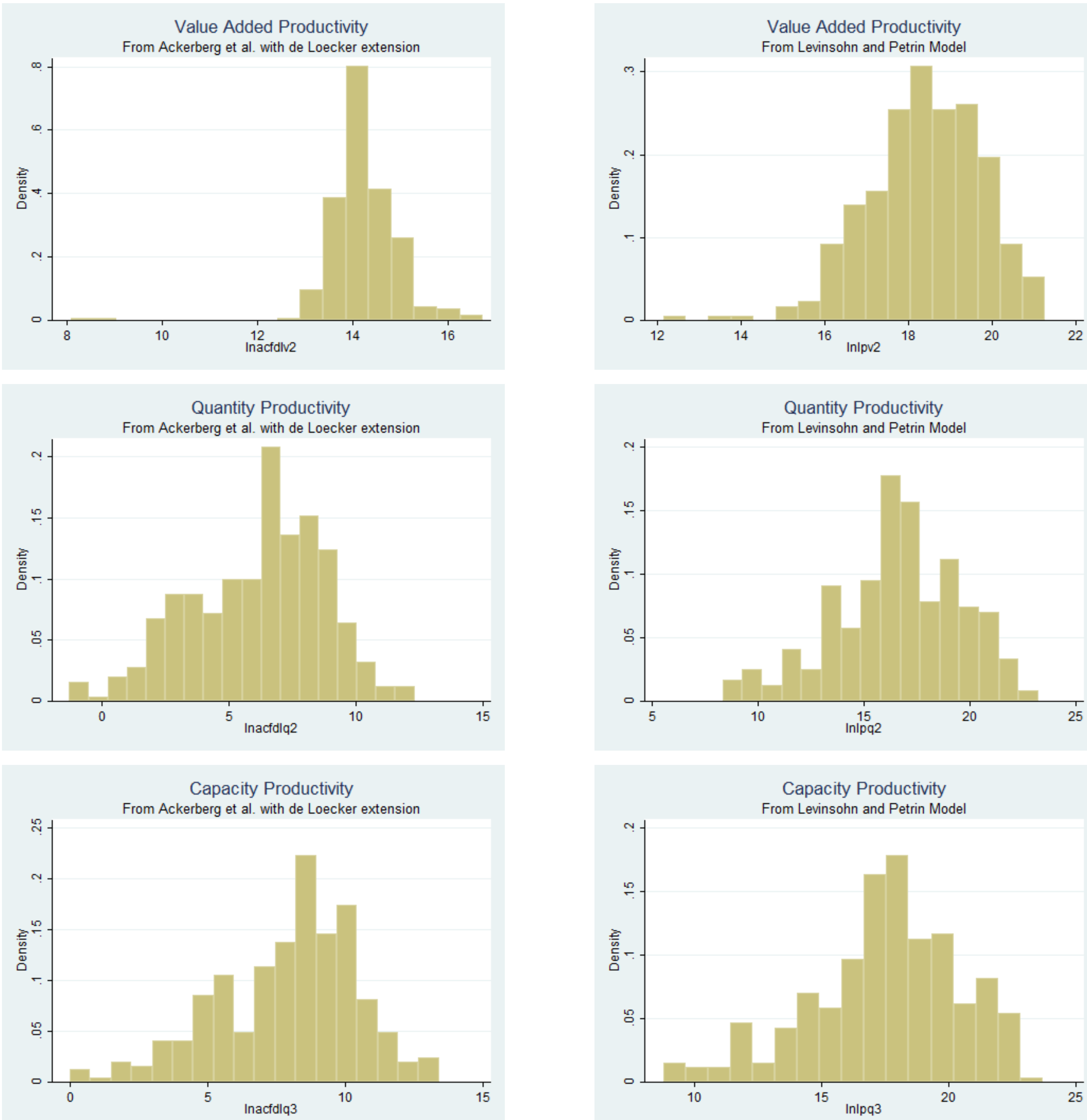

Figure 3.2: Productivity Estimates of Radio, Television, and Communication Equipment Sector

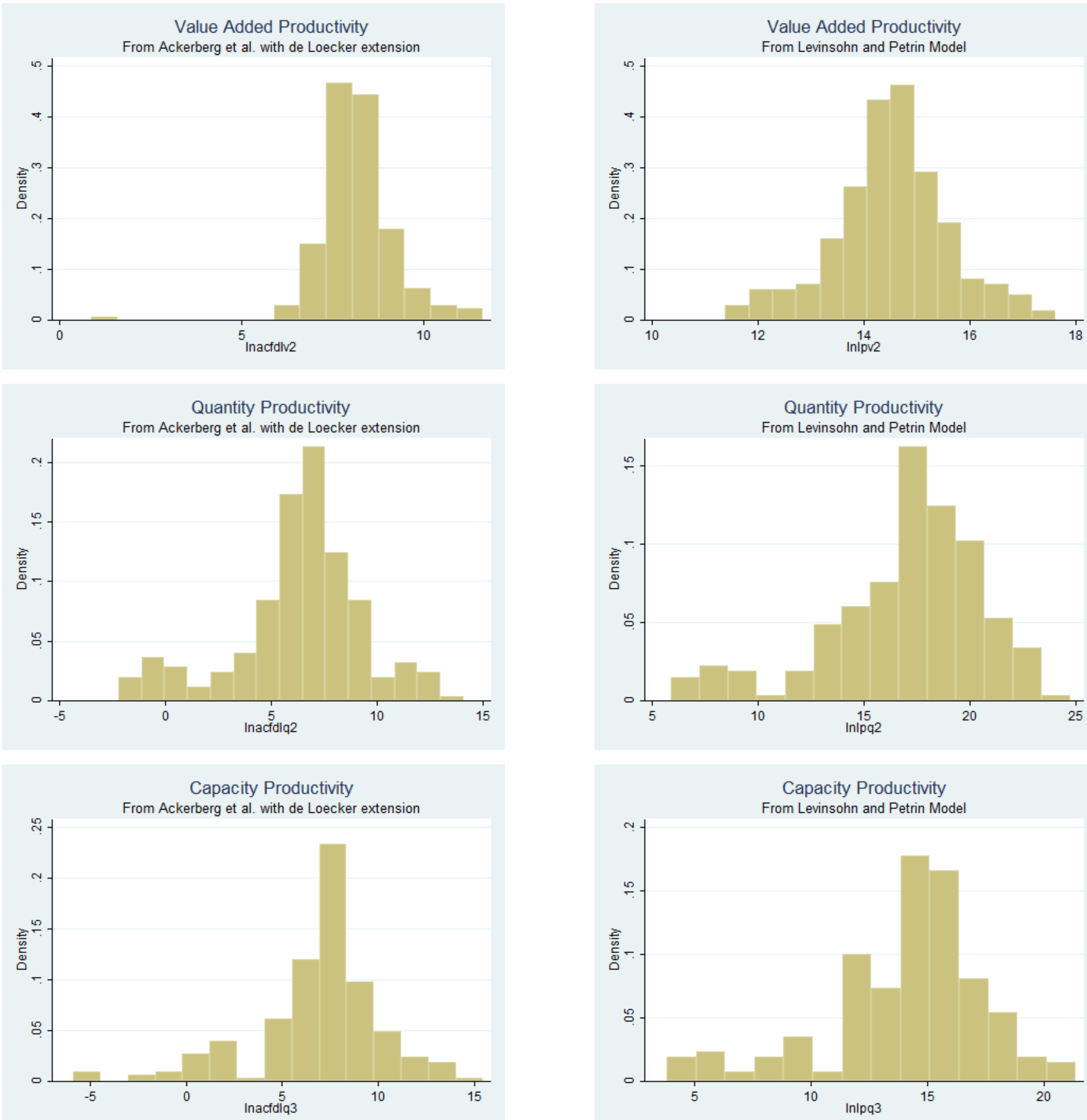

Figure 3.3: Productivity Estimates of Motor Vehicle, Trailer and Semi-Trailer Sector

Appendix

Table 3.2: Production Function Results of ISIC 15, 17, 18

Food Products and Beverages (ISIC 15)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.242***	0.238***	0.210	0.293***	0.047*	0.058***	0.055	0.370***	0.098***	0.109***	0.004	0.247***
	(0.030)	(0.021)	(0.255)	(0.067)	(0.028)	(0.019)	(0.189)	(0.130)	(0.027)	(0.019)	(0.237)	(0.173)
Unskilled	0.213***	0.243***	0.324	0.856***	0.054**	0.086***	0.000	0.480***	0.033	0.072***	0.001	0.840***
	(0.027)	(0.019)	(0.268)	(0.145)	(0.024)	(0.019)	(0.234)	(0.187)	(0.023)	(0.019)	(0.235)	(0.283)
Machinery	0.163***	0.098	0.000	0.125**	0.199**	0.000	0.055	0.290***	0.102**	0.172	0.005	0.195**
	(0.064)	(0.174)	(0.037)	(0.051)	(0.096)	(0.153)	(0.203)	(0.075)	(0.045)	(0.130)	(0.233)	(0.091)
No. of		-0.089***		-0.089***		-0.268***		-0.281***		-0.278***		-0.291***
Product lines		(0.034)		(0.033)		(0.036)		(0.036)		(0.037)		(0.037)
Returns to Scale	0.618	0.579	0.535	1.273	0.301	0.143	0.110	1.141	0.233	0.353	0.010	1.283

Textiles (ISIC 17)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.206***	0.217***	0.055	0.277	0.114***	0.120***	0.026	0.546**	0.116***	0.107***	0.001	0.374
	(0.027)	(0.024)	(0.297)	(0.214)	(0.030)	(0.028)	(0.240)	(0.265)	(0.024)	(0.020)	(0.244)	(0.234)
Unskilled	0.191***	0.192***	0.112	0.720*	0.081**	0.082***	0.049	0.538	0.073***	0.080***	0.021	0.471
	(0.029)	(0.024)	(0.189)	(0.375)	(0.034)	(0.028)	(0.251)	(0.412)	(0.028)	(0.021)	(0.243)	(0.324)
Machinery	0.051	0.150	0.016	0.048	0.030	0.193	0.114	0.057	0.079	0.222**	0.029	0.120***
	(0.035)	(0.123)	(0.014)	(0.082)	(0.068)	(0.120)	(0.235)	(0.054)	(0.055)	(0.109)	(0.240)	(0.047)
No. of		0.019		0.039		0.293***		0.573***		-0.059		-0.078
Product lines		(0.049)		(0.050)		(0.068)		(0.063)		(0.061)		(0.063)
Returns to Scale	0.448	0.559	0.183	1.045	0.225	0.395	0.189	1.141	0.268	0.409	0.051	0.965

Wearing Apparel; Dressing and Dyeing of Fur (ISIC 18)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.155***	0.156***	0.003	0.389**	0.066**	0.068***	0.505***	0.339***	0.108***	0.112***	0.000	0.331***
	(0.026)	(0.020)	(0.229)	(0.155)	(0.031)	(0.025)	(0.100)	(0.119)	(0.035)	(0.022)	(0.234)	(0.129)
Unskilled	0.233***	0.231***	0.001	0.806***	0.156***	0.154***	0.522***	0.815***	0.199***	0.194**	0.001	0.930***
	(0.027)	(0.022)	(0.183)	(0.295)	(0.040)	(0.027)	(0.157)	(0.298)	(0.034)	(0.026)	(0.242)	(0.361)
Machinery	0.082**	0.109	0.001	0.064	0.018	0.000	0.374**	0.072	-0.035	0.331	0.000	0.040
	(0.039)	(0.181)	(0.047)	(0.090)	(0.125)	(0.173)	(0.108)	(0.165)	(0.091)	(0.243)	(0.240)	(0.142)
No. of		-0.005		0.008		-0.101		-0.118*		-0.117*		-0.152**
Product lines		(0.051)		(0.050)		(0.072)		(0.071)		(0.068)		(0.069)
Returns to Scale	0.47	0.496	0.005	1.259	0.24	0.222	1.401	1.226	0.272	0.637	0.001	1.301

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

Table 3.3: Production Function Results of ISIC 19, 20, 21

Tanning and Dressing of Leather (ISIC 19)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.187***	0.172***	0.133	0.285*	0.050	0.095**	0.003	0.171	0.074	0.140***	0.001	0.154
	(0.043)	(0.035)	(0.258)	(0.155)	(0.062)	(0.041)	(0.222)	(0.210)	(0.047)	(0.034)	(0.214)	(0.193)
Unskilled	0.244***	0.222***	0.001	0.709**	0.052	0.139***	0.000	0.725**	0.095*	0.182***	0.053	0.891***
	(0.048)	(0.041)	(0.243)	(0.307)	(0.054)	(0.046)	(0.259)	(0.361)	(0.056)	(0.039)	(0.232)	(0.355)
Machinery	0.089	0.245	0.060	0.102	0.098	0.512**	0.002	0.170	-0.019	0.519**	0.049	0.230
	(0.089)	(0.335)	(0.069)	(0.099)	(0.180)	(0.258)	(0.228)	(0.147)	(0.203)	(0.254)	(0.217)	(0.163)
No. of		0.189***		0.189***		-0.201*		-0.162		-0.438***		-0.444***
Product lines		(0.059)		(0.073)		(0.106)		(0.119)		(0.088)		(0.094)
Returns to Scale	0.519	0.639	0.193	1.096	0.200	0.747	0.004	1.066	0.149	0.841	0.103	1.275

Wood and Products of Wood, Except Furniture (ISIC 20)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.249***	0.253***	0.026	0.624***	0.168	0.171*	0.500**	0.034	0.249**	0.239***	0.500**	0.547**
	(0.081)	(0.069)	(0.108)	(0.241)	(0.132)	(0.102)	(0.211)	(0.225)	(0.117)	(0.081)	(0.206)	(0.275)
Unskilled	0.174	0.156*	0.103	0.000	-0.016	-0.092	0.500**	0.030	0.096	0.038	0.501**	0.506
	(0.123)	(0.088)	(0.252)	(0.417)	(0.144)	(0.115)	(0.204)	(0.436)	(0.113)	(0.093)	(0.228)	(0.345)
Machinery	-0.367	0.359	0.000	0.077	-0.106	0.231	0.500**	0.549**	-0.225	0.483**	0.500**	0.129
	(0.464)	(0.338)	(0.194)	(0.305)	(0.467)	(0.262)	(0.250)	(0.229)	(0.367)	(0.267)	(0.215)	(0.201)
No. of		-0.235***		-0.224		-0.583**		-0.780***		-0.713***		-0.765***
Product lines		(0.114)		(0.177)		(0.228)		(0.228)		(0.182)		(0.174)
Returns to Scale	0.056	0.769	0.129	0.701	0.047	0.310	1.500	0.612	0.120	0.760	1.500	1.181

Paper and Paper Products (ISIC 21)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.158***	0.163***	0.744*	0.583**	0.056	0.053	0.500**	0.404*	0.055	0.008	0.030	0.238
	(0.051)	(0.035)	(0.406)	(0.230)	(0.060)	(0.045)	(0.151)	(0.224)	(0.045)	(0.046)	(0.234)	(0.183)
Unskilled	0.249***	0.264***	0.000	0.730**	0.218***	0.214***	0.500**	0.718**	0.135***	0.139***	0.005	0.461
	(0.054)	(0.035)	(0.244)	(0.296)	(0.081)	(0.048)	(0.231)	(0.298)	(0.061)	(0.043)	(0.242)	(0.359)
Machinery	-0.080	0.402*	0.006	0.088	0.354**	0.561**	0.500***	0.244	0.357***	0.576***	0.002	0.337**
	(0.090)	(0.216)	(0.168)	(0.120)	(0.143)	(0.221)	(0.128)	(0.150)	(0.090)	(0.103)	(0.216)	(0.138)
No. of		0.153***		0.177***		0.055		0.106		0.658***		0.646***
Product lines		(0.051)		(0.052)		(0.111)		(0.106)		(0.082)		(0.078)
Returns to Scale	0.326	0.829	0.750	1.401	0.628	0.828	1.500	1.365	0.129	0.257	0.228	1.185

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 3.4: Production Function Results of ISIC 22, 24, 25

Publishing, Printing and Reproduction of Recorded Media (ISIC 22)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.163***	0.185***	0.146	0.246	-0.067	-0.056	0.003	0.169	0.010	0.025	0.001	0.000
	(0.063)	(0.043)	(0.245)	(0.227)	(0.065)	(0.048)	(0.251)	(0.300)	(0.056)	(0.041)	(0.249)	(0.300)
Unskilled	0.149***	0.145***	0.265	0.831**	0.217***	0.199***	0.000	0.865*	0.121**	0.094**	0.038	0.139
	(0.064)	(0.035)	(0.238)	(0.335)	(0.079)	(0.044)	(0.264)	(0.461)	(0.061)	(0.039)	(0.280)	(0.455)
Machinery	0.093*	0.275	0.000	0.029	0.058	0.189	0.001	0.075	0.073	0.432*	0.023	0.883***
	(0.048)	(0.182)	(0.026)	(0.058)	(0.058)	(0.149)	(0.241)	(0.131)	(0.116)	(0.252)	(0.242)	(0.168)
No. of		-0.154***		-0.094		-0.153*		-0.115		-0.274***		-0.134
Product lines		(0.060)		(0.062)		(0.085)		(0.094)		(0.077)		(0.084)
Returns to Scale	0.405	0.605	0.411	1.106	0.208	0.332	0.004	1.109	0.204	0.551	0.062	1.022
Chemicals and Chemical Products (ISIC 24)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.228***	0.175***	0.014	0.214	0.012	0.049	0.365	0.428	-0.007	0.029	0.050	0.259
	(0.052)	(0.042)	(0.159)	(0.199)	(0.075)	(0.047)	(0.229)	(0.278)	(0.066)	(0.040)	(0.209)	(0.272)
Unskilled	0.123***	0.105***	0.004	0.706**	0.033	0.130***	0.470*	0.077	-0.005	0.070**	0.380	0.442
	(0.041)	(0.032)	(0.258)	(0.328)	(0.073)	(0.038)	(0.250)	(0.333)	(0.060)	(0.032)	(0.246)	(0.363)
Machinery	0.278*	0.296	0.014	0.334***	-0.099	0.636***	0.001	0.414***	-0.082	0.564**	0.001	0.376***
	(0.144)	(0.193)	(0.052)	(0.090)	(0.156)	(0.272)	(0.232)	(0.129)	(0.128)	(0.273)	(0.230)	(0.138)
No. of		-0.160***		-0.155***		-0.133*		-0.140*		-0.188***		-0.244***
Product lines		(0.057)		(0.058)		(0.074)		(0.077)		(0.066)		(0.070)
Returns to Scale	0.629	0.576	0.032	1.255	-0.054	0.815	0.835	0.920	-0.094	0.663	0.431	1.077
Rubber and Plastics Products (ISIC 25)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.248***	0.243***	0.512*	0.518***	0.073	0.134***	0.001	0.293	0.130***	0.173***	0.000	0.135
	(0.044)	(0.025)	(0.270)	(0.122)	(0.076)	(0.037)	(0.242)	(0.209)	(0.062)	(0.032)	(0.233)	(0.148)
Unskilled	0.240***	0.233***	0.449*	0.330	0.087**	0.119***	0.000	0.711***	0.069*	0.093**	0.337	0.877**
	(0.032)	(0.023)	(0.233)	(0.236)	(0.043)	(0.033)	(0.237)	(0.257)	(0.039)	(0.030)	(0.246)	(0.318)
Machinery	0.110**	0.421**	0.000	0.196***	0.097	0.370***	0.001	0.067	-0.021	0.403**	0.056	0.065
	(0.064)	(0.204)	(0.059)	(0.075)	(0.095)	(0.103)	(0.245)	(0.080)	(0.082)	(0.159)	(0.243)	(0.110)
No. of		0.050		0.024		0.146**		0.248***		0.083		0.215**
Product lines		(0.046)		(0.044)		(0.070)		(0.069)		(0.064)		(0.063)
Returns to Scale	0.599	0.897	0.961	1.043	0.256	0.623	0.002	1.071	0.179	0.669	0.393	1.077

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 3.5: Production Function Results of ISIC 2610, 2691, 2692

Glass in the Mass, Rods or Tubes (ISIC 2610)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.287**	0.251***	0.410***	0.565**	0.380**	0.355***	0.000	0.207	0.380**	0.283***	0.001	0.098
	(0.141)	(0.072)	(0.118)	(0.279)	(0.174)	(0.081)	(0.253)	(0.409)	(0.174)	(0.078)	(0.238)	(0.311)
Unskilled	0.270	0.303***	0.281***	0.318	-0.038	-0.014	0.006	0.448	-0.038	-0.087	0.001	0.326
	(0.172)	(0.118)	(0.086)	(0.321)	(0.165)	(0.121)	(0.269)	(0.424)	(0.165)	(0.099)	(0.228)	(0.378)
Machinery	0.082	0.212	0.014	0.286	-0.094	0.000	0.000	0.718***	-0.094	0.000	0.001	0.831***
	(0.172)	(0.258)	(0.047)	(0.191)	(0.233)	(0.253)	(0.234)	(0.276)	(0.273)	(0.280)	(0.216)	(0.254)
No. of		0.384**		0.324*		0.380*		0.350***		0.288		0.290***
Product lines		(0.192)		(0.186)		(0.210)		(0.124)		(0.201)		(0.111)
Returns to Scale	0.639	0.766	0.705	1.169	0.248	0.341	0.006	1.373	0.248	0.195	0.003	1.255

Ceramic Tableware, Kitchenware (ISIC 2691)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.264***	0.261***	0.001	0.387**	0.177***	0.189***	0.052	0.111	0.177**	0.260***	0.000	0.320
	(0.042)	(0.031)	(0.195)	(0.150)	(0.069)	(0.045)	(0.237)	(0.237)	(0.069)	(0.055)	(0.223)	(0.221)
Unskilled	0.238***	0.241***	0.001	0.858***	-0.016	-0.018	0.000	0.857***	-0.016	0.010	0.007	0.258
	(0.046)	(0.035)	(0.165)	(0.261)	(0.083)	(0.046)	(0.267)	(0.313)	(0.083)	(0.056)	(0.247)	(0.294)
Machinery	0.094	0.000	0.050	0.027	0.046	0.000	0.165	0.001	0.046	0.000	0.210	0.483***
	(0.120)	(0.223)	(0.063)	(0.149)	(0.148)	(0.240)	(0.216)	(0.240)	(0.166)	(0.281)	(0.201)	(0.175)
No. of		0.042		0.015		-0.251***		-0.252***		-0.129		-0.079
Product lines		(0.061)		(0.059)		(0.090)		(0.088)		(0.116)		(0.128)
Returns to Scale	0.596	0.502	0.052	1.272	0.207	0.171	0.218	0.968	0.207	0.270	0.217	1.062

Unfired Refractory Products; Other Refractory Ceramic Goods (ISIC 2692)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.384***	0.249***	0.248	0.400	0.232***	0.066	0.064	0.403	0.232***	0.297***	0.000	0.001
	(0.098)	(0.062)	(0.286)	(0.295)	(0.076)	(0.055)	(0.289)	(0.360)	(0.076)	(0.070)	(0.233)	(0.325)
Unskilled	0.068	0.195***	0.366	0.144	-0.049	0.003	0.001	0.809*	-0.049	-0.157*	0.000	0.434*
	(0.092)	(0.073)	(0.327)	(0.325)	(0.094)	(0.045)	(0.275)	(0.463)	(0.094)	(0.089)	(0.245)	(0.236)
Machinery	0.585***	0.355*	0.070	0.445***	0.667*	0.453**	0.097	0.506*	0.667***	0.071	0.000	0.281
	(0.222)	(0.206)	(0.052)	(0.198)	(0.381)	(0.215)	(0.205)	(0.298)	(0.144)	(0.266)	(0.200)	(0.302)
No. of		-0.232		-0.118		-0.390***		0.371***		-0.140		-0.332*
Product lines		(0.166)		(0.155)		(0.099)		(0.139)		(0.206)		(0.191)
Returns to Scale	1.037	0.798	0.684	0.990	0.849	0.522	0.162	1.718	0.849	0.211	0.000	0.716

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

Table 3.6: Production Function Results of ISIC 2695, 27, 28

Articles of Asbestos-Cement, Cellulose Fibre-Cement (ISIC 2695)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.169***	0.191***	0.000	0.577**	0.061	0.066	0.000	0.944**	0.061	0.007	0.128	0.727**
	(0.060)	(0.050)	(0.194)	(0.242)	(0.064)	(0.055)	(0.244)	(0.412)	(0.064)	(0.062)	(0.226)	(0.363)
Unskilled	0.161**	0.164***	0.000	0.558*	0.006	0.003	0.378	0.718*	0.006	-0.030	0.001	0.580*
	(0.076)	(0.043)	(0.209)	(0.314)	(0.066)	(0.045)	(0.231)	(0.435)	(0.066)	(0.050)	(0.245)	(0.325)
Machinery	-0.056	0.000	0.000	0.028	-0.027	0.453**	0.002	0.001	-0.027	0.472**	0.000	0.013
	(0.057)	(0.189)	(0.030)	(0.048)	(0.148)	(0.200)	(0.233)	(0.149)	(0.126)	(0.211)	(0.231)	(0.123)
No. of		-0.190**		-0.177**		-0.390***		-0.484***		-0.461***		-0.479***
Product lines		(0.074)		(0.071)		(0.099)		(0.111)		(0.116)		(0.144)
Returns to Scale	0.274	0.355	0.000	1.163	0.039	0.522	0.381	1.663	0.039	0.449	0.129	1.320

Basic Metals (ISIC 27)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.351***	0.292***	0.000	0.688***	0.210***	0.246***	0.000	0.627**	0.131**	0.130***	0.020	0.127
	(0.116)	(0.085)	(0.184)	(0.246)	(0.075)	(0.071)	(0.249)	(0.316)	(0.061)	(0.047)	(0.221)	(0.342)
Unskilled	0.256**	0.260***	0.284	0.260	0.120*	0.093	0.000	0.226	0.031	0.011	0.006	0.871**
	(0.103)	(0.080)	(0.236)	(0.331)	(0.067)	(0.067)	(0.232)	(0.436)	(0.055)	(0.046)	(0.209)	(0.340)
Machinery	0.087	0.001	0.083	0.186	0.005	0.031	0.211	0.082	0.239	0.385	0.379**	0.000
	(0.182)	(0.371)	(0.104)	(0.082)	(0.270)	(0.198)	(0.168)	(0.209)	(0.237)	(0.253)	(0.178)	(0.246)
No. of		0.142		0.119		0.246**		-0.023		0.138		0.061
Product lines		(0.114)		(0.111)		(0.118)		(0.133)		(0.087)		(0.089)
Returns to Scale	0.694	0.553	0.368	1.133	0.334	0.370	0.211	0.934	0.401	0.526	0.406	0.997

Fabricated Metal Products (ISIC 28)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.226***	0.205***	0.117	0.654***	0.134	0.135	0.000	0.511**	0.037	0.074	0.136	0.001
	(0.076)	(0.069)	(0.227)	(0.255)	(0.104)	(0.097)	(0.262)	(0.242)	(0.083)	(0.076)	(0.254)	(0.395)
Unskilled	0.124	0.120**	0.086	0.000	-0.060	0.019	0.031	0.000	-0.014	0.049	0.012	0.697**
	(0.083)	(0.056)	(0.159)	(0.233)	(0.102)	(0.072)	(0.261)	(0.371)	(0.085)	(0.056)	(0.252)	(0.283)
Machinery	-0.088	0.000	0.037	0.091	0.092	0.000	0.070	0.630*	0.037	0.059	0.010	0.005
	(0.219)	(0.370)	(0.258)	(0.272)	(0.367)	(0.389)	(0.250)	(0.326)	(0.316)	(0.231)	(0.244)	(0.294)
No. of		0.185**		0.212***		0.670***		0.761***		0.272**		0.391***
Product lines		(0.079)		(0.074)		(0.123)		(0.119)		(0.107)		(0.105)
Returns to Scale	0.261	0.325	0.239	0.745	0.166	0.155	0.102	1.142	0.060	0.181	0.157	0.703

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

Table 3.7: Production Function Results 29, 31, 32

Machinery and Equipment (ISIC 29)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.214***	0.185***	0.016	0.250	0.043	-0.001	0.043	0.706**	0.026	0.034	0.000	0.553*
	(0.076)	(0.045)	(0.328)	(0.231)	(0.093)	(0.065)	(0.233)	(0.344)	(0.077)	(0.053)	(0.244)	(0.332)
Unskilled	0.148*	0.153***	0.000	0.554*	0.016	0.046	0.119	0.001	0.006	0.042	0.074	0.051
	(0.079)	(0.043)	(0.285)	(0.296)	(0.075)	(0.064)	(0.219)	(0.421)	(0.058)	(0.053)	(0.309)	(0.443)
Machinery	0.405*	0.470**	0.023	0.316**	0.392	0.528	0.051	0.380**	0.372*	0.487	0.054	0.417**
	(0.222)	(0.201)	(0.036)	(0.087)	(0.256)	(0.357)	(0.211)	(0.187)	(0.201)	(0.326)	(0.226)	(0.202)
No. of		0.053		0.041		0.304***		0.324***		-0.213**		-0.325***
Product lines		(0.064)		(0.061)		(0.104)		(0.111)		(0.102)		(0.107)
Returns to Scale	0.768	0.808	0.039	1.120	0.451	0.573	0.213	1.087	0.404	0.563	0.129	1.020

Electrical Machinery and Apparatus (ISIC31)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.199***	0.206***	0.037	0.232	-0.058	-0.005	0.000	0.024	-0.012	0.038	0.000	0.075
	(0.062)	(0.048)	(0.357)	(0.198)	(0.072)	(0.069)	(0.264)	(0.384)	(0.047)	(0.042)	(0.220)	(0.267)
Unskilled	0.144***	0.135***	0.077	0.533*	0.061	0.062	0.000	0.871**	0.137**	0.115**	0.646**	0.786**
	(0.055)	(0.040)	(0.294)	(0.289)	(0.082)	(0.060)	(0.308)	(0.427)	(0.067)	(0.039)	(0.282)	(0.378)
Machinery	0.043	0.506**	0.000	0.149	0.248	0.562**	0.001	0.088	-0.064	0.475*	0.000	0.241
	(0.076)	(0.241)	(0.055)	(0.105)	(0.304)	(0.223)	(0.205)	(0.120)	(0.068)	(0.247)	(0.224)	(0.182)
No. of		0.071		0.054		-0.250		-0.126		-0.424***		-0.448***
Product lines		(0.061)		(0.062)		(0.135)		(0.138)		(0.093)		(0.097)
Returns to Scale	0.385	0.847	0.114	0.914	0.251	0.619	0.001	0.983	0.061	0.628	0.646	1.101

Radio, Television and Communication Equipment and Apparatus (ISIC 32)

Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.237***	0.253***	0.577	0.499**	-0.253***	-0.226***	0.001	0.059	-0.137*	-0.124**	0.001	0.026
	(0.076)	(0.050)	(0.360)	(0.198)	(0.075)	(0.062)	(0.259)	(0.335)	(0.072)	(0.049)	(0.238)	(0.316)
Unskilled	0.214**	0.222***	0.285	0.626**	-0.119	-0.136**	0.001	0.881**	0.022	-0.002	0.001	0.705*
	(0.064)	(0.043)	(0.188)	(0.266)	(0.077)	(0.060)	(0.272)	(0.414)	(0.065)	(0.050)	(0.318)	(0.376)
Machinery	-0.070	0.000	0.000	0.024	-0.001	0.632**	0.000	0.051	-0.068	0.046	0.001	0.014
	(0.058)	(0.202)	(0.070)	(0.043)	(0.111)	(0.321)	(0.231)	(0.180)	(0.072)	(0.245)	(0.231)	(0.179)
No. of		-0.175**		-0.109		0.113		0.024		-0.028		-0.020
Product lines		(0.086)		(0.096)		(0.131)		(0.134)		(0.107)		(0.107)
Returns to Scale	0.381	0.475	0.863	1.149	-0.373	0.270	0.001	0.990	-0.183	-0.080	0.003	0.746

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

Table 3.8: Production Function Results of ISIC 34, 36

Motor Vehicles, Trailers and Semi-Trailers (ISIC 34)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.131**	0.133***	0.000	0.123	0.018	-0.007	0.003	0.840**	0.036	0.009	0.000	0.375
	(0.055)	(0.043)	(0.210)	(0.218)	(0.060)	(0.050)	(0.269)	(0.393)	(0.068)	(0.046)	(0.240)	(0.304)
Unskilled	0.124***	0.117**	0.000	0.789***	0.081	0.032	0.004	0.257	0.110	0.065	0.054	0.689**
	(0.046)	(0.046)	(0.263)	(0.325)	(0.059)	(0.060)	(0.322)	(0.416)	(0.072)	(0.057)	(0.275)	(0.317)
Machinery	0.185	0.071	0.000	0.293**	-0.255	0.880**	0.000	0.140	-0.077	0.547	0.000	0.096
	(0.143)	(0.216)	(0.045)	(0.133)	(0.276)	(0.379)	(0.231)	(0.287)	(0.115)	(0.381)	(0.227)	(0.249)
No. of		0.054		0.055		-0.391***		-0.512***		-0.548***		-0.460***
Product lines		(0.069)		(0.078)		(0.102)		(0.119)		(0.096)		(0.123)
Returns to Scale	0.441	0.321	0.000	1.204	-0.156	0.905	0.007	1.237	0.068	0.622	0.054	1.161
Furniture (ISIC 36)												
Output	Value Added				Quantity				Capacity			
Model	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL	LP	LPDL	ACF	ACFDL
Skilled	0.161***	0.119***	0.000	0.324***	-0.031	-0.087**	0.059	0.149	0.011	-0.058	0.021	0.014
	(0.053)	(0.042)	(0.149)	(0.118)	(0.067)	(0.042)	(0.231)	(0.184)	(0.064)	(0.047)	(0.238)	(0.132)
Unskilled	0.219***	0.226***	0.014	0.644***	0.030	0.095**	0.037	0.632*	0.059	0.178***	0.015	0.632**
	(0.056)	(0.040)	(0.211)	(0.247)	(0.059)	(0.042)	(0.250)	(0.355)	(0.056)	(0.045)	(0.234)	(0.303)
Machinery	0.079	0.029	0.003	0.119	-0.124	0.843***	0.136	0.000	-0.261	0.719**	0.005	0.000
	(0.087)	(0.231)	(0.042)	(0.144)	(0.270)	(0.324)	(0.222)	(0.178)	(0.342)	(0.228)	(0.227)	(0.204)
No. of		0.135**		0.142***		-0.137		-0.182**		0.125		-0.009
Product lines		(0.054)		(0.052)		(0.088)		(0.087)		(0.082)		(0.085)
Returns to Scale	0.459	0.374	0.017	1.086	-0.125	0.851	0.231	0.781	-0.191	0.838	0.041	0.647

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Note: LP=Levinsohn and Petrin(2003), LPDL=Levinsohn and Petrin with De Loecker extension,

ACF = Ackerberg, Caves, and Frazer(2006), ACFDL=Ackerberg, Caves, and Frazer(2006) with with De Loecker extension

Table 3.9: Demand Shifter Coefficients of ISIC 15

Sector	Food Products and Beverages (ISIC 15)					
Output	Value Added		Quantity		Capacity	
Model / ISIC 4	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
1511	0.028***	0.035***	0.050***	0.049***	0.036***	0.037***
	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)
1512	0.035***	0.039***	0.037***	0.036***	0.026***	0.027***
	(0.007)	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)
1513	0.046***	0.051***	0.058***	0.057***	0.044***	0.046***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.011)	(0.011)
1514	0.047***	0.037***	0.042***	0.039***	0.034***	0.032***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)
1530	0.041***	0.040***	0.053***	0.049***	0.044***	0.040***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.011)	(0.011)
1531	0.037***	0.037***	0.057***	0.055***	0.043***	0.042***
	(0.01)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
1532	0.055***	0.061***	0.104***	0.096***	0.086***	0.086***
	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
1533	0.051***	0.050***	0.056***	0.053***	0.044***	0.042***
	(0.008)	(0.007)	(0.009)	(0.009)	(0.010)	(0.010)
1541	0.063***	0.063***	0.068***	0.065***	0.050***	0.050***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)
1542	0.028***	0.026***	0.053***	0.047***	0.022***	0.016***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)
1543	0.063***	0.066***	0.061***	0.059***	0.043***	0.045***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.014)	(0.014)
1544	0.046***	0.052***	0.056***	0.052***	0.042***	0.039***
	(0.009)	(0.008)	(0.011)	(0.011)	(0.012)	(0.012)
1549	0.066***	0.068***	0.049***	0.045***	0.034***	0.032***
	(0.008)	(0.008)	(0.010)	(0.01)	(0.01)	(0.01)
1551	0.064***	0.063***	0.053***	0.050***	0.034***	0.036***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)	(0.011)
1553	0.100***	0.090***	0.100***	0.089***	0.083***	0.060***
	(0.011)	(0.011)	(0.013)	(0.013)	(0.013)	(0.014)
1554	0.056***	0.058***	0.080***	0.078***	0.063***	0.060***
	(0.008)	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.10: Demand Shifter Coefficients of ISIC 17, 18, 19

Sector	Textiles (ISIC 17)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
1711	0.044***	0.044***	0.046***	0.037***	0.013*	0.014*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.007)	(0.008)
1712	0.050***	0.047***	0.072***	0.064***	0.033***	0.037***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.007)	(0.007)
1721	0.053***	0.050***	0.051***	0.022	0.013	0.005
	(0.012)	(0.012)	(0.016)	(0.016)	(0.012)	(0.012)
1722	0.087***	0.090***	0.071***	0.059***	0.019	0.026*
	(0.018)	(0.017)	(0.018)	(0.018)	(0.014)	(0.014)
1729	0.057***	0.057***	0.045***	0.035***	0.013	0.016
	(0.011)	(0.011)	(0.012)	(0.012)	(0.008)	(0.008)
1730	0.062***	0.067***	0.058***	0.04***1	0.013	0.018
	(0.012)	(0.012)	(0.015)	(0.015)	(0.011)	(0.011)
Sector	Wearing Apparel; Dressing and Dyeing of Fur (ISIC 18)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
1810	0.131***	0.140***	0.026*	0.024	0.037**	0.035**
	(0.034)	(0.034)	(0.015)	(0.015)	(0.015)	(0.015)
Sector	Tanning and Dressing of Leather (ISIC 19)					
Output	ValueAdded		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
1911	0.080*	0.052	0.036	0.054	0.026	0.050
	(0.046)	(0.059)	(0.033)	(0.036)	(0.030)	(0.030)
1912	0.076*	0.059	-0.008	0.006	-0.030	-0.004
	(0.045)	(0.055)	(0.037)	(0.039)	(0.033)	(0.033)
1920	0.083*	0.066	0.031	0.043	0.010	0.032
	(0.043)	(0.054)	(0.036)	(0.038)	(0.033)	(0.032)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.11: Demand Shifter Coefficients of ISIC 20, 21, 22

Sector	Wood and Products of Wood, Except Furniture (ISIC 20)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2010	-0.069	-0.100	0.204*	0.119	0.105	0.089
	(0.074)	(0.105)	(0.121)	(0.127)	(0.100)	(0.104)
2021	-0.072	-0.098	0.137	0.069	0.081	0.065
	(0.062)	(0.085)	(0.090)	(0.093)	(0.074)	(0.077)
2022	-0.096	-0.088	0.184	0.086	0.113	0.086
	(0.071)	(0.102)	(0.126)	(0.131)	(0.105)	(0.108)

Sector	Paper and Paper Products (ISIC 21)					
Output	ValueAdded		Quantity		Capacity	
Model ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2101	0.105**	0.084*	-0.068***	-0.072***	-0.053**	-0.061***
	(0.049)	(0.048)	(0.026)	(0.025)	(0.024)	(0.024)
2102	0.080	0.064	-0.083***	-0.086***	-0.071***	-0.078***
	(0.049)	(0.048)	(0.028)	(0.028)	(0.026)	(0.026)
2109	0.100**	0.088*	-0.074***	-0.084***	-0.064**	-0.068***
	(0.050)	(0.049)	(0.029)	(0.028)	(0.027)	(0.027)

Sector	Publishing, Printing and Reproduction of Recorded Media (ISIC 22)					
Output	ValueAdded		Quantity		Capacity	
Model ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2221	-0.010	0.018	0.089	0.083	0.120*	-0.001
	(0.042)	(0.044)	(0.067)	(0.071)	(0.062)	(0.067)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.12: Demand Shifter Coefficients of ISIC 24, 25

Sector	Chemicals and Chemical Products (ISIC 24)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2411	0.069***	0.069***	0.085***	0.087***	0.069***	0.049***
	(0.011)	(0.011)	(0.012)	(0.013)	(0.012)	(0.014)
2413	0.046***	0.043***	0.058***	0.060***	0.044***	0.025*
	(0.011)	(0.011)	(0.013)	(0.014)	(0.012)	(0.014)
2422	0.073***	0.072***	0.054***	0.056***	0.041***	0.019
	(0.014)	(0.013)	(0.015)	(0.016)	(0.015)	(0.017)
2423	0.092***	0.090***	0.048***	0.055***	0.034**	0.013
	(0.014)	(0.014)	(0.016)	(0.017)	(0.015)	(0.018)
2424	0.080***	0.079***	0.053***	0.057***	0.045***	0.019
	(0.013)	(0.013)	(0.015)	(0.016)	(0.014)	(0.016)
2429	0.071***	0.075***	0.053***	0.059***	0.049***	0.025
	(0.022)	(0.022)	(0.020)	(0.021)	(0.017)	(0.021)
2430	0.052***	0.057***	0.029*	0.034*	0.019	-0.002
	(0.014)	(0.014)	(0.017)	(0.018)	(0.016)	(0.019)
Sector	Rubber and Plastics Products (ISIC 25)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2511	0.094***	0.103***	0.052*	0.042	0.063**	0.049*
	(0.020)	(0.019)	(0.031)	(0.030)	(0.029)	(0.028)
2519	0.088***	0.097***	0.118***	0.117***	0.117***	0.115***
	(0.018)	(0.017)	(0.025)	(0.024)	(0.022)	(0.022)
2520	0.099***	0.105***	0.115***	0.110***	0.111***	0.108***
	(0.020)	(0.019)	(0.026)	(0.025)	(0.024)	(0.024)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.13: Demand Shifter Coefficients of ISIC 2691, 2692

Sector	Ceramic Tableware, Kitchenware (ISIC 2691)					
Output	ValueAdded		Quantity		Capacity	
Model ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2691	0.057	0.016	-0.064	-0.093	-0.087	-0.127*
	(0.111)	(0.108)	(0.062)	(0.060)	(0.080)	(0.079)

Sector	Unfired Refractory Products & Ceramic (ISIC 2692)					
Output	Value Added		Quantity		Capacity	
Model ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2610	0.092	0.116	0.039	-0.137	0.044	-0.058
	(0.101)	(0.125)	(0.109)	(0.137)	(0.114)	(0.134)
2691	-0.041	0.012	0.359	0.548	0.701*	0.327
	(0.225)	(0.219)	(0.377)	(0.389)	(0.380)	(0.318)
2692	0.092	-0.005	-0.069	-0.141	-0.192***	-0.132**
	(0.124)	(0.122)	(0.075)	(0.074)	(0.073)	(0.059)
2693	0.091	0.001	-0.058	-0.127	-0.168**	-0.104
	(0.125)	(0.124)	(0.080)	(0.078)	(0.078)	(0.064)
2694	0.095	0.006	-0.033	-0.083	-0.120**	-0.070**
	(0.105)	(0.104)	(0.056)	(0.055)	(0.055)	(0.044)
2695	0.087	0.084	0.139	0.296	0.192**	0.367***
	(0.131)	(0.155)	(0.081)	(0.106)	(0.084)	(0.112)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.14: Demand Shifter Coefficients of ISIC 2695, 27, 28

Sector	Articles of Asbestos-Cement, Cellulose Fibre-Cement (ISIC 2695)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2610	0.152	0.176	0.028	-0.055	0.022	-0.440
	(0.121)	(0.111)	(0.105)	(0.134)	(0.128)	(0.347)
2692	0.037	0.036	0.011	-0.010	0.049	-0.137
	(0.103)	(0.101)	(0.136)	(0.145)	(0.164)	(0.269)
2694	0.106	0.090	0.239***	0.340***	0.220**	0.888***
	(0.100)	(0.084)	(0.074)	(0.101)	(0.092)	(0.344)
2695	0.077	0.070	0.073**	0.075**	0.093**	0.075*
	(0.069)	(0.068)	(0.033)	(0.035)	(0.039)	(0.043)
Sector	Basic Metals (ISIC 27)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2710	0.028	0.029	0.127***	0.161***	0.113***	0.089***
	(0.037)	(0.036)	(0.034)	(0.035)	(0.025)	(0.024)
2720	0.051	0.044	0.126***	0.165***	0.101***	0.061***
	(0.040)	(0.039)	(0.035)	(0.036)	(0.026)	(0.026)
2731	0.084*	0.099**	0.224***	0.279***	0.198***	0.155***
	(0.049)	(0.047)	(0.050)	(0.053)	(0.037)	(0.036)
Sector	Fabricated Metal Products (ISIC 28)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2811	0.089	0.068	-0.041	-0.020	0.092**	0.091**
	(0.058)	(0.055)	(0.047)	(0.047)	(0.040)	(0.040)
2812	0.113*	0.104	-0.034	0.016	0.150***	0.168***
	(0.058)	(0.055)	(0.068)	(0.069)	(0.058)	(0.059)
2891	0.089	0.074	-0.002	0.013	0.135***	0.130***
	(0.073)	(0.068)	(0.058)	(0.058)	(0.049)	(0.048)
2892	0.105*	0.075	0.015	0.040	0.127***	0.127***
	(0.059)	(0.056)	(0.043)	(0.043)	(0.036)	(0.036)
2893	0.103*	0.075	-0.043	-0.011	0.111***	0.116***
	(0.056)	(0.053)	(0.051)	(0.051)	(0.044)	(0.044)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.15: Demand Shifter Coefficients of ISIC 29, 31

Sector	Machinery and Equipment (ISIC 29)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
2911	0.088***	0.092***	0.043	0.077**	0.068**	0.045
	(0.015)	(0.015)	(0.035)	(0.034)	(0.031)	(0.032)
2912	0.070***	0.078***	0.014	0.037	0.045	0.016
	(0.020)	(0.019)	(0.034)	(0.033)	(0.030)	(0.030)
2913	0.093***	0.097***	0.055**	0.061**	0.069***	0.045**
	(0.017)	(0.016)	(0.025)	(0.024)	(0.022)	(0.022)
2914	0.110***	0.115***	0.043	0.055	0.096*	0.042
	(0.028)	(0.027)	(0.060)	(0.057)	(0.053)	(0.054)
2915	0.070***	0.090***	0.022	0.017	0.046	0.014
	(0.018)	(0.017)	(0.040)	(0.038)	(0.035)	(0.036)
2919	0.060***	0.068***	0.026	0.053	0.045*	0.017
	(0.014)	(0.013)	(0.031)	(0.030)	(0.027)	(0.027)
2922	0.082***	0.095***	-0.010	0.001	0.019	-0.011
	(0.018)	(0.018)	(0.033)	(0.032)	(0.029)	(0.030)
2925	0.118***	0.130***	0.046	0.107	0.100	0.057
	(0.039)	(0.038)	(0.087)	(0.082)	(0.077)	(0.078)
2929	0.090***	0.074***	0.023	0.059	0.055	0.031
	(0.025)	(0.024)	(0.038)	(0.036)	(0.034)	(0.035)
2930	0.048***	0.054***	-0.015	0.020	0.004	-0.020
	(0.014)	(0.013)	(0.033)	(0.031)	(0.029)	(0.029)

Sector	Electrical Machinery and Apparatus (ISIC31)					
Output	Value Added		Quantity		Capacity	
Model ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
3110	0.071***	0.069**	0.058	0.072	0.033	0.020
	(0.028)	(0.028)	(0.066)	(0.066)	(0.047)	(0.046)
3120	0.059**	0.055*	0.024	0.042	0.004	-0.006
	(0.028)	(0.029)	(0.061)	(0.061)	(0.043)	(0.043)
3130	0.066***	0.063**	0.054	0.057	0.027	0.015
	(0.026)	(0.027)	(0.060)	(0.060)	(0.043)	(0.042)
3140	0.081***	0.083***	0.055	0.064	0.027	0.012
	(0.029)	(0.029)	(0.072)	(0.072)	(0.051)	(0.051)
3150	0.097***	0.094***	0.126*	0.142**	0.095*	0.080
	(0.033)	(0.032)	(0.071)	(0.071)	(0.050)	(0.049)
3190	0.063**	0.062**	0.058	0.069	0.031	0.019
	(0.025)	(0.026)	(0.060)	(0.060)	(0.043)	(0.043)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

Table 3.16: Demand Shifter Coefficients of ISIC 32, 34, 36

Sector	Radio, Television and Communication Equipment (ISIC 32)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
3210	0.001	-0.038	0.150***	0.131***	0.151***	0.133***
	(0.045)	(0.043)	(0.025)	(0.026)	(0.020)	(0.023)
3220	-0.004	-0.031	0.165***	0.155***	0.169***	0.169***
	(0.054)	(0.052)	(0.026)	(0.027)	(0.022)	(0.025)
3230	0.008	-0.033	0.181***	0.155***	0.181***	0.170***
	(0.053)	(0.052)	(0.034)	(0.035)	(0.027)	(0.031)

Sector	Motor Vehicles, Trailers and Semi-Trailers (ISIC 34)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
3410	0.077***	0.077***	-0.013	-0.024	0.001	-0.016
	(0.022)	(0.022)	(0.028)	(0.028)	(0.028)	(0.029)
3420	0.080**	0.086**	-0.013	-0.017	-0.022	-0.022
	(0.033)	(0.034)	(0.031)	(0.032)	(0.032)	(0.034)
3430	0.084***	0.085***	0.007	-0.001	0.007	-0.001
	(0.026)	(0.026)	(0.023)	(0.023)	(0.022)	(0.024)

Sector	Furniture (ISIC 36)					
Output	Value Added		Quantity		Capacity	
Model / ISIC	LPDL	ACFDL	LPDL	ACFDL	LPDL	ACFDL
3610	0.017	0.029	0.006	0.001	-0.009	-0.001
	(0.036)	(0.032)	(0.025)	(0.025)	(0.029)	(0.029)
3691	0.040	0.051	0.053**	0.045**	0.042	0.046*
	(0.037)	(0.033)	(0.022)	(0.022)	(0.026)	(0.026)
3693	0.021	0.029	0.050*	0.043	0.042	0.054*
	(0.039)	(0.035)	(0.027)	(0.027)	(0.031)	(0.032)
3694	0.055	0.077***	0.077**	0.064**	0.085**	0.099***
	(0.037)	(0.033)	(0.030)	(0.030)	(0.035)	(0.034)

Standard errors are in parentheses, *** indicates p-value<0.01,

** indicates p-value<0.05, and * indicates p-value<0.1

See definition of each industry at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=2

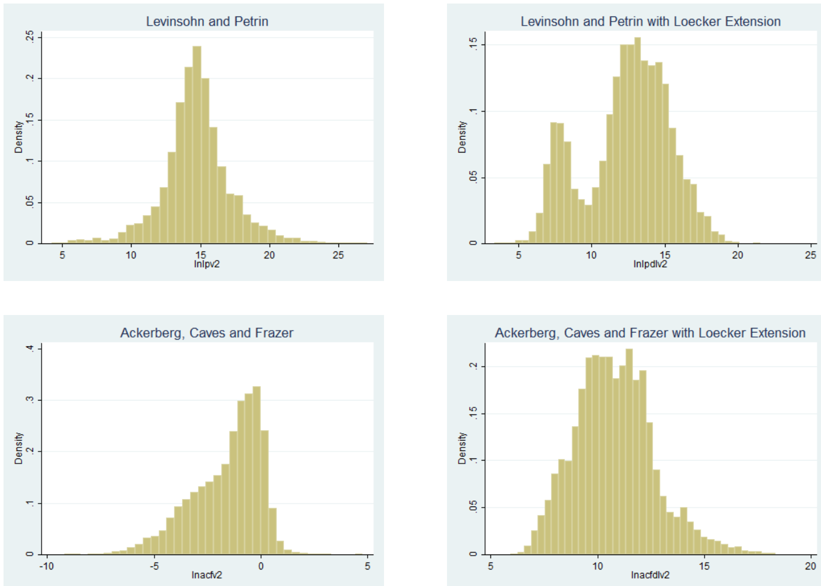

Figure 3.4: Productivity Estimates in Terms of Value Added from Four Models

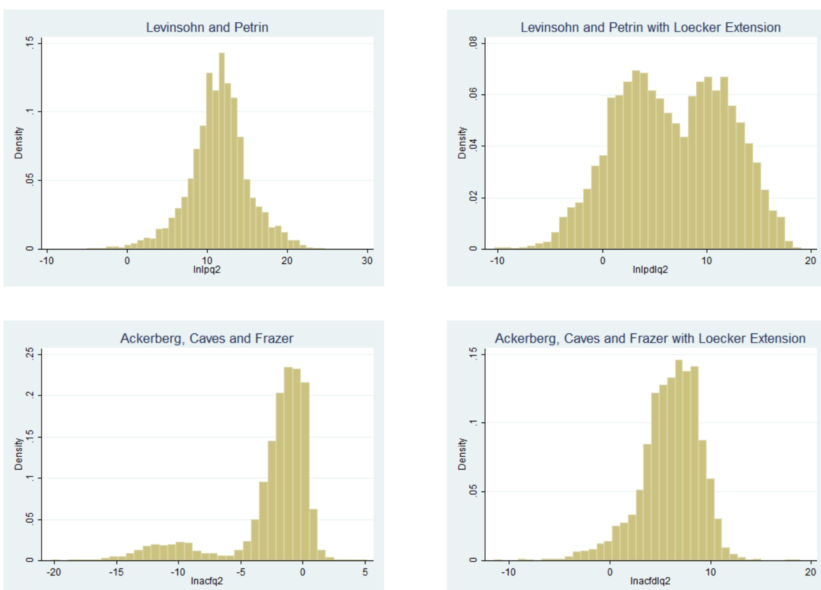

Figure 3.5: Productivity Estimates in Terms of Quantity from Four Models

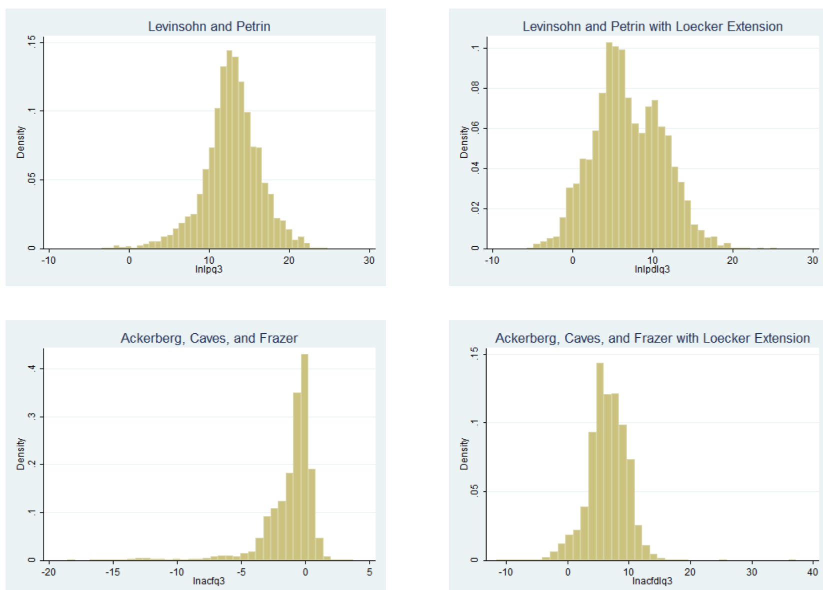

Figure 3.6: Productivity Estimates in Terms of Full Capacity Output from Four Models

Chapter 4

Foreign Direct Investment Effects on Local Affiliates: Parenting or Exploiting?

4.1 Introduction

During the Asian financial crisis in 1997-1998, Asian companies that were afflicted by the sudden drop in asset prices desperately sought foreign partners or buyers. An intervention by the IMF forced countries in the region to relax regulations such that foreign investors were able to buy Asian companies at devalued prices. After the crisis, Asian countries were furiously competing to attract FDI inflows. Since the financial regulations were relaxed, the FDI inflows to the countries in the region have retained high levels.

Financial support, technological and managerial knowledge are expected to be directly transferred from foreign owners to local affiliates. If the technologies of the local firms are less advanced compared to the multinational investors, then this technology transfer may enhance the productivity of the local affiliates. On the other hand, some highly productive local firms may benefit from the marketing utility of multinational firms instead of technology transfer and thus FDI does not enhance productivity of these firms but still increases sales. Furthermore, multinational firms may simply seek market access in the host country without transferring knowledge to local affiliates. Therefore, whether foreign ownership increases a local firm's productivity is an empirical question.

In this chapter, I examine whether FDI increases local affiliates' productivity.[18] I employ firm-level data from the Thai manufacturing sectors between 2001 and 2006 and several productivity estimates from Chapter 3. The key identification issue is that foreign ownership may be endogenous; multinationals may select to invest in local firms based on observed and unobserved information that is systematically related to productivity. I tackle this identification issues in two ways.

First, for most foreign owned firms I do not observe what their productivity would have been if they were not foreign owned. Therefore it is not straightforward to identify the impact of foreign ownership on productivity. To solve this problem I employ a propensity score matching estimator to estimate the average treatment effect (ATT). This estimator identifies the average impact of

[18] Since local affiliates and subsidiaries of multinational firms in a host country are often referred to as foreign firms in the literature, the terms will be used interchangeably throughout the analysis.

foreign ownership on productivity when ex ante outcomes are not observed while accounting for selection on observables.

In my second approach I adopt a control function estimator proposed by Farre et al. (2010).[19] This estimator has several advantages. The estimator controls for endogenous foreign ownership, but does not rely on instrumental variables which are difficult to obtain at the firm level. Instead, the approach constructs a control variable that captures unobserved common factors that determine productivity and the share of foreign ownership. In addition, while the matching estimator relies on an indicator variable to distinguish whether a firm is foreign owned or not, the control-variable estimator allows for variation in the degree of foreign ownership. An alternative and very common approach is to exploit the panel nature of the data and account for unobservable information via firm-level fixed effects. The difficulty with that approach is that foreign ownership has little variation within firms. This empirical fact highlights the importance of developing an estimation approach that exploits the cross-section variation of the data while accounting for unobserved information.

To estimate the impact of foreign ownership on productivity I employ productivity estimates based on value added and physical output. If the direct effect is significant for value added productivity but insignificant for quantity, then I conclude that FDI increases product values rather than physical efficiency. On the other hand, if the estimates are significant for only quantity productivity, it suggests the existence of FDI direct effect on production efficiency of affiliates but not their product prices.

The ATT results show that the direct effect from FDI exists in ten sectors, and four of them are high-FDI sectors.[20] Three sectors have significant ATT only for value added productivity. Three sectors have significant ATT only for quantity productivity. Four sectors have significant ATT for both value added and quantity productivity. Results based on the control function estimator show

[19] For examples of applications of this approach see Farre et al. (2010), Klein and Vella (2009) and Millimet and Roy (2011) for pollution study example

[20] Chemical products, Rubber and plastic products, communication equipments, and Motor vehicle.

that the share of foreign ownership has a significant impact on productivity in seven sectors for value added and in nine sectors for quantity productivity. These findings suggest that the share of foreign ownership has a significant impact on product prices of affiliates in seven sectors and on production efficiency in nine sectors. Overall these results suggest that while foreign ownership seems to impact firm performance, the magnitude, significance and source are heterogeneous across sectors. Policy makers have to evaluate whether it is worth to spend resources to attract FDI. To understand the benefits of FDI it is important to identify how foreign ownership impacts domestic productivity.

In the next section, I review literature on FDI and the estimation methodology. In section 4.3, the empirical procedures are described. In section 4.4 I discuss the results. The last section concludes.

4.2 Literature

I distinguish two channels by which foreign ownership impacts productivity of domestic firms: a direct effect and an indirect spillover effect. The direct effect is driven by foreign firms transferring their knowledge and technology to their local affiliates and raising the affiliates' productivity. The indirect spillover effect suggests that locally owned firms benefit from FDI because the improved productivity of foreign owned firms spills over to the locally owned firms. Although we would expect that foreign ownership increases the domestic productivity via a direct effect, most previous studies focus only on the existence of indirect spillover effects.

The few papers that examine direct effects using firm-level data from developing countries find mixed results for the direct effect. Haddad and Harrison (1993) using Moroccan data and Aitken and Harrison (1999) working with Venezuelan data find that foreign firms are more productive than domestic competitors. Similarly, Suyanto et al. (2009), using data from chemical and pharmaceutical industries in Indonesia, finds superior productivity of foreign owned firms. None of these studies seriously consider the potential endogeneity of foreign ownership. On the contrary, the results from Kathuria (2002), using Indian data indicate no productivity differences between foreign owned and locally owned firms.

Unlike the above studies that considered only horizontal relationship in the spillover test, Javorcik (2004) accounts for both horizontal and vertical relationships and finds inconsistent results for the direct effect. When differencing variables in the specification, she finds no significant direct effect but a large significant effect in a specification in levels. These results are actually consistent with other studies that applied the same techniques. Haddad and Harrison (1993) and Aitken and Harrison (1999) specify productivity in levels and find that foreign firms are more productive. Kathuria (2002) first differences a specification that relates output to foreign ownership and finds no direct effect.

The main issue with first differencing is that while it accounts for unobserved firm level information to solve the problem of endogenous foreign ownership, identification requires variation in foreign ownership within firms. Spillover effects are easier to identify in differences than direct effects because within the industry as a whole FDI inflows may vary sufficiently while the status of foreign ownership of a particular firm is fairly stable. The specification in levels on the other hand benefits from cross section variation but does not account for endogenous foreign ownership. I employ two estimation techniques that exploit cross section variation while accounting for endogenous foreign ownership. An additional advantage of the control function approach is that it exploits variation in the share of foreign ownership across firms instead of only variation in the status of ownership via a indicator variable.

To identify the impact of foreign ownership on productivity requires information about foreign and locally owned firms' productivity. Aitken and Harrison (1999) did not explicitly estimate total factor productivity but measured firm outcomes with log real output and included input variables in the estimation functions. In contrast, Haddad and Harrison (1993) estimated productivity but assumed productivity a time invariant variable. The difficulty with this approach is that according to recent productivity estimation that I discuss in Chapter 3, firm level productivity is time varying and cannot be absorbed with firm specific fixed effects. This raises an omitted variable concern in specifications that employ output as dependent variable even if the specification is in differences. In contrast, Kathuria (2002) and Suyanto et al. (2009) estimated total factor productivity from stochastic frontier method and Javorcik (2004) estimated total factor productivity from Olley and Pakes (1996)'s method. As discussed in Chapter 3, I employ recent estimation techniques that solve various identification problems to estimate firm level productivity.

4.3 Empirical Estimation

4.3.1 Average Treatment Effect on the Treated Based on Propensity Score Matching

The main interest here is to investigate how FDI impacts the productivity of local affiliates/subsidiaries in Thailand. This method compares the productivity of local affiliates/subsidiaries with productivity of local firms that have the most similar characteristics.

I assume for this approach that spillover effects do not exist. If these indirect effects exist but are excluded, then I expect that the overall treatment effect is underestimated, because in that case the productivities of the locally owned firms (the control group) are higher than what they would be if there is no foreign ownership.

To estimate effects of FDI on local affiliates/subsidiaries, a problem arises because counterfactual outcomes cannot be observed. Instead I match locally owned firms with the most similar characteristics to the foreign owned firms as counterfactual subjects. Because there are many covariates that determine firm characteristics, a propensity score matching procedure reduces the multidimensional characteristics of firms into one scalar which is the probability that firms receive (or not receive) FDI conditional on a set of idiosyncratic variables as suggested by Rosenbaum and Rubin (1983). This method controls for endogeneity since the firms with the most similar unobserved factors should have the most similar characteristics and hence behave similarly. Given the similarity in characteristics and behaviors, their outcome differences due to differences in foreign ownership are meaningful.

In this context, the average treatment effect is given by $ATT = E[y_i^1 - y_i^0 | w = 1]$ where w is a dummy variable indicating whether firm i has foreign share in equity, y_i^1 denotes productivity of foreign firms, and y_i^0 is productivity of firm i if it is not foreign owned. The problem that arises here is that y_i^0 is unobserved because firm i cannot have two statuses in the same time period. If firm i is foreign owned, its observed productivity in that time period is y_i^1. To obtain a comparable y_i^0 for each firm, I estimate the propensity score then match locally-owned firms with the nearest propensity score with foreign owned firms and use the productivity of that locally-owned firm as y_i^0 for the matched foreign firm.

I obtain the propensity score with a standard probit function conditional on a set of covariates. The propensity score captures weights of characteristics that are observable for each firm. The nearest-neighbor matching will find the counterfactual firms whose propensity scores are least different from each foreign firm. In other words, a foreign firm i that shares the most similar characteristic with a locally-owned firm j will have the nearest values of propensity score[21]. The observed characteristic variables included in the covariate set to estimate propensity score should have the same conditional distribution in both the treated and control groups so that their outcomes are comparable. This is called the balancing property. Therefore I will include only covariates that satisfy the balancing property of each sector.

The average treatment effect on the treated using propensity score matching can be estimated by

$$\widehat{ATT} = \frac{1}{N^f} \sum_{i \in f} y_i^1 - \frac{1}{N^f} \sum_{j \in d} \hat{p}_j(X_i) y_j^0 \qquad (4.1)$$

where N^f is number of foreign firms, $\hat{p}_j(X_j)$ is the propensity score of each domestic firm, y_i^1 is productivity of foreign firm i, and y_j^0 is productivity of locally-owned firm j. This estimate

[21] See Becker and Ichino(2002) for details

indicates whether FDI makes local affiliates/subsidiaries more productive than they would have been without FDI.

4.3.2 A Parametric Control Function Approach Based on Conditional Second Moments

One limitation of the average treatment effect on the treated based on propensity score matching is that it does not account for the intensity of FDI share. In addition, the matching estimator accounts for selection on observables, but foreign ownership may be endogenous with respect to unobservable information. To examine robustness of the foreign ownership impact on productivity I apply the estimation procedure developed by Farre et al. (2010) The structural model can be written as the outcome function

$$y_{it} = X_{it}B_0 + \beta_1 g_{it} + \varepsilon_{it} \tag{4.2}$$

and the treatment function

$$g_{it} = X_{it}\Upsilon_0 + v_{it}. \tag{4.3}$$

y_{it} denotes the outcome of individual i, X_{it} is a set of observed covariates, g_{it} is a choice variable, and the error terms of the outcome and choice functions are denoted by ε_{it} and v_{it} respectively.

The endogeneity problem stems from the unobserved common factors that simultaneously determine productivity and the share of foreign ownership. These common factors are contained in ε_{it} and v_{it}. Therefore there exists correlation between ε_{it} and g_{it} in equation (4.2) when I substitute g_{it} from equation (4.3) into equation (4.2) and causes biased estimates of β_1. Moreover multicollinearity will arise because X_{it} enters both equations.

The model proposed by Klein and Vella (2009) provides an endogeneity correction in the above setting using conditional second moments.[22] With this approach, no instrumental variable is required and the same covariates can enter both functions.

[22] In their paper, they consider the return to education on wage which suffers an endogeneity problem due to unobserved factors embodied in both the wage and education function.

Klein and Vella (2009) decomposed the residuals of the outcome function into two elements: the residual of the treatment function and an i.i.d disturbance term. Two key assumptions are imposed. First, both the variances of the errors vary with covariates which will be used to capture heteroskedasticity in the outcome function. Second, the residual of the outcome function is additive in the residual of the treatment function and an i.i.d disturbance. Then, the product of the treatment function residuals and ratio of estimated standard errors from both functions are used as a control variable for heteroskedasticity in the outcome function. Farre et al. (2010) show how one can use this trick to account for the endogeneity of g_{it} and the disturbance in the outcome function.[23]

To estimate the impact of foreign ownership on productivity specify the outcome function as

$$tfp_{it} = X_{it}B_0 + \beta_1 fdishare_{it} + \varepsilon_{it} \tag{4.4}$$

and the treatment function as

$$fdishare_{it} = X_{it}\Upsilon_0 + v_{it}. \tag{4.5}$$

tfp_{it} denotes the productivity of firm i at time t, X_{it} is a set of observed covariates, and $fdishare_{it}$ is the foreign share of the firm's equity taking values from 0 to 1. The error terms of productivity and foreign ownership functions are denoted by ε_{it} and v_{it} respectively.

Assume ε_{it} and v_{it} are not correlated with X_{it}. Then the first moment conditions are $E[\varepsilon_{it}X_{it}] = 0$ and $E[v_{it}X_{it}] = 0$. Therefore X_{it} is exogenous and can enter both equation 4.4 and 4.5. Since $fdishare_{it}$ enters the productivity function, the common component driving both v_{it} and ε_{it} will lead to $E[\varepsilon_{it}v_{it}] \neq 0$. As a result, the estimate of β_1 is biased due to endogeneity. This common unobserved component, that simultaneously determine the FDI decision and the productivity functions, may come from two possible forces. First, highly productive local firms may choose to attract a greater foreign share of total equity to expand production. In this case the effect of FDI on

[23] Unlike the dataset employed by Klein and Vella (2009) and Farre et al. (2010) I have panel data. Therefore I include time fixed effects into the specification as well as industry fixed effect. As a robustness exercise I also estimate the specifications by year to be consistent with their cross section approach.

local affiliates may be overstated because the affiliates are already highly productive. Second, the multinational firms may choose to engage with very low productive local firms, who might have exited without financial support, for the cheap facilities, and thus the FDI direct effects may be understated.

Following Klein and Vella (2009), let ε_{it} be a function of v_{it} and an i.i.d disturbance such that

$$\varepsilon_{it} = \lambda_0 v_{it} + \varepsilon_{it} \tag{4.6}$$

where $\lambda_0 = \frac{cov(\varepsilon_{it} v_{it})}{\sigma_v^2}$, and σ_v^2 is the homoskedastic variance of v_{it}. If one substitutes ε_{it} into equation (4.4) , an unbiased estimate of β_1 should be obtained. However, the coefficients in equation (4.4) are not identified because v_{it} embodied in $fdishare_{it}$ is linearly dependent with $\lambda_0 v_{it}$. This means we could not disentangle the impact of foreign ownership from λ_0. To identify the coefficients of the right hand side variables, λ_0 must dependent on X_{it}.

Let $S_\varepsilon^2(X_{it})$ denote the conditional variance of the productivity function, and $S_v^2(X_{it})$ denote the conditional variance of the foreign share function. Then equation (4.6) becomes

$$\varepsilon_{it} = A(X_{it}) v_{it} + \varepsilon_{it} \tag{4.7}$$

Klein and Vella (2009) show that

$$A(X_{it}) = \frac{cov(\varepsilon_{it} v_{it} | X_{it})}{S_v^2} = \rho_0 \left(\frac{S_\varepsilon(X_{it})}{S_v(X_{it})} \right) \tag{4.8}$$

where $\rho_0 = [cov(\varepsilon_{it} v_{it} | X_{it} = x_{it}) / S_\varepsilon(X_{it}) \cdot S_v(X_{it})]$, which is a constant, and $A(X_{it})$ is a nonlinear function of X_{it}. Then equation (4.7) becomes

$$\varepsilon_{it} = \rho_0 \left(\frac{S_\varepsilon(X_{it})}{S_v(X_{it})} \right) \cdot v_{it} + \varepsilon_{it} \tag{4.9}$$

If we can measure $\rho_0 \left(\frac{S_\varepsilon(X_{it})}{S_v(X_{it})}\right) \cdot v_{it}$ with observable data, then we can plug this term back into the outcome function and estimate β_1 consistently from

$$tfp_{it} = X_{it}B_0 + \beta_1 fdishare_{it} + \rho_0 \left(\frac{S_\varepsilon(X_{it})}{S_v(X_{it})}\right) \cdot v_{it} + \varepsilon_{it} \tag{4.10}$$

I follow Farre et al. (2010)'s strategy to obtain $A(X_{it})$ by parametrically estimating the conditional variance. As in Klein and Vella (2009), define the conditional variance function as

$$S^2_{jit} = exp(X_{1it} + X_{2it}\theta_j) \tag{4.11}$$

where j is either ε or v, X_{1it} is one of the covariates whose coefficient will be suppressed to 1, X_{2it} is a vector of the other covariates, and θ_j is the vector of parameters corresponding to X_{2it} in S^2_{jit}. Then, Farre et al. (2010) outline the following steps to develop a proxy for the unobserved term $A(X_{it})$ and v_{it}.

1. Obtain $\hat{v}_{it}$ by estimating residuals from a generalized linear model (GLM) of $fdishare_{it}$ on X_{it} where all variables in X_{it} are in level terms.[24]

2. Estimate $\hat{\theta}_v$ from Nonlinear Least Squares (NLS) of this exponential equation, $\hat{v}^2_{it} = exp(X_{1it} + X_{2it}\theta_v)$.[25] Then compute $\hat{S}_v(X_{it}) = \sqrt{exp(X_{1it} + X_{2it}\hat{\theta}_v)}$.

3. Use $\hat{v}_{it}$ and $\hat{S}_v(X_{it})$ to estimate:

$$\min_{B_0,\beta_1,\theta_u,\rho_0} \sum_{i=1}^{N} \left[tfp_{it} - X_{it}B_0 - \beta_1 fdishare_{it} - \rho_0 \left(\sqrt{exp(X_{1it} + X_{2it}\theta_\varepsilon}\right) \cdot \left(\frac{\hat{v}_{it}}{\hat{S}_{vit}}\right)\right]^2 \tag{4.12}$$

4. Obtain $\hat{\varepsilon}_{it} = tfp_{it} - X_{it}\tilde{B}_0 - \tilde{\beta}_1 fdishare_{it}$ where $\tilde{B}_0$ and $\tilde{\beta}_1$ are estimates from equation (4.12).

5. Estimate $\hat{\theta}_u$ from Nonlinear Least Squares (NLS) of $\hat{\varepsilon}^2_{it} = exp(X_{1it} + X_{2it}\theta_\varepsilon)$.[26] Then com-

[24] Farre et al. (2010) obtain $\hat{v}_{it}$ by an Ordinary Least Squared Regression (OLS) of the treatment variable on covariates. I apply GLM because the foreign share variable is a fraction taking values between 0 and 1.

[25] In practice, I use OLS to regress $ln(\hat{v}^2_{it})$ on log terms of all covariates in X_{it} and suppress coefficient of X_{1it} equal to 1.

[26] Carry out the same strategy as step 2 for $\hat{u}^2_{it}$.

pute $\hat{S}_\varepsilon(X_{it}) = \sqrt{exp(X_{1it} + X_{2it}\hat{\theta}_\varepsilon)}$

6. Compute $w_{it} = \left(\hat{S}_u(X_{it})/\hat{S}_v(X_{it})\right) \cdot \hat{v}_{it}$.

7. Substitute $\varepsilon_{it} = \rho_0 w_{it} + \varepsilon_{it}$ in equation (4.7) which is equation (4.10). Then estimate equation 4.10 with OLS.

4.4 Data

This chapter uses firm-level data from the manufacturing sector in Thailand during 2001-2006 to estimate the FDI effect on the productivity of local affiliates or subsidiaries of multinational firms. Firms are categorized as foreign firms when they have a foreign share at least 10% of equity. With this definition, I have to drop 2 sectors from the analysis due to insufficient observations of foreign firms in the sample, which leaves 16 sectors in the estimations.

I use productivity estimates from Chapter 3 as the measures of outcomes for the firms, and I use the ratio of foreign share to total equity as the FDI variable, which takes values from 0 to 1. I employ productivity estimates based on value added and physical output.

A set of firm characteristic variables will be selected to compute propensity scores in the average treatment effect estimation. The selected variables have to maintain the balance property in each sector so that the outcome differences have a meaningful interpretation. Therefore each of the sectors will have different characteristic variables. The firm characteristic variables provided in the Thai dataset are age, registered funds, age structure of machinery[27], marketing costs, and R&D expenditure. In addition, I construct five variables from production and sales information: the firm's market share, the firm's markup, the capital-labor ratio, the ratio of domestic material costs to total material costs, and a dummy variable for export firms. Since there are so many firms that do not have R&D expenditure, I replace the R&D expenditure variable with a dummy variable equal to 1 if firms have R&D expenditure and 0 otherwise. The treatment variable in ATT estima-

[27] Firms reported percentages of machinery value by age to the value of all machinery. There are four age ranges, newer than 4 years, 4 years to 6 years, 7 years to 10 years and older than 10 years.

tion is a dummy variable equal to 1 if firms have a foreign share in equity of at least 10% and 0 otherwise. Table 4.1 lists the variables that I use to match firms by sector. Table 4.2 provides the summary statistics for the estimation sample.

In the control function approach, 8 variables determine productivity changes. In addition I include industry-specific and year dummy variables in both, the productivity and foreign share functions. Therefore X_{it} consists of a firm's market share, the firm's markup, the firm's age, an export dummy, an R&D dummy, and the machinery age structure variables.[28] The foreign share in equity takes values from 0 to 1[29]. The firm's market share variable captures the firms' competitiveness, which also determines productivity, while the firm's markup variable accounts for the profitability of the firm. Since the older firms may be more productive than the new ones, I include the firm's age variable in the set of covariates. In addition, if firms have more new machinery, their productivity may be higher. Thus I add machinery age structure to the covariates. In addition, I include a dummy variable for firm size equal to 1 if firm i is medium size who have registered capital at least one million Bahts but not more than 100 million Bahts. To estimate the conditional variance I choose to suppress the coefficient of firm's market share to 1.[30]

In the next section I describe the results from both estimation approaches. Both approaches are carried out for each sector using both value added and quantity productivity. I present OLS estimates for comparison.

[28]To avoid multicollinearity in the estimation among percent of machinery value by age ranges, I ignore percent of old machinery.

[29]Firms with foreign share of 1 are the firms owned by foreigners whereas firms with foreign share of 0 are the firms owned by Thais

[30]I tried suppressing coefficient of each variable and market share gives the best results for all sectors.

4.5 Results

4.5.1 Average Treatment Effect on the Treated

Table 4.3 summarizes the impact of foreign ownership on productivity according to the matching estimator for 16 sectors. I report estimates for 6 different types of productivity measures. Columns 2 and 3 report estimates based on the productivity measures I develop in Chapter 3. Columns 4 and 5 report estimates based on Levinsohn and Petrin's productivity estimates as explained in Chapter 3. Columns 6 and 7 extend the Levinsohn and Petrin (2003) estimates to account for demand shifters as introduced by De Loecker (2007). Again, for details see Chapter 3. For all productivity estimates I report estimation results based on a value added and a physical output based estimation routine. The last two columns report the number of locally and foreign owned firms present in the estimation sample by sector.

The ATT results show that FDI has significant effects on affiliates' productivity in 10 sectors, and 4 of them, which are chemical products, rubber and plastic products, communication equipments, and motor vehicles, have high FDI concentration during the sample periods. To emphasize the direct effect of FDI, I focus on the results for the high-FDI sectors and two major production sectors with low-FDI, which are Food and Textiles.

The ATT estimates of the Food sector are insignificant for both types of productivity estimates. This indicates that FDI in food sector does not impact the productivity of their local affiliates. Unlike the Food sector, the ATT estimates of the Textile sector are significant for both value added and quantity productivity. This reflects that FDI enhances the productivity of their local affiliates in Textile sector, although FDI inflows to this sector in Thailand are very low. Apparently, in the textile sector foreign firms have more efficient production technology and gain more value added while foreign owned firms in Food sectors are not different from Thai firms.

For high-FDI sectors, the chemicals and chemical product and rubber and plastic product sectors have significant ATT estimates for both types of productivity estimates, while the ATT estimates of the fabricated metal product and machinery and equipment sectors are insignificant for both types of productivity estimates. The communication equipment and motor vehicle sectors, which received the highest FDI inflows during the sample period, have significant ATT estimates only for value added productivity. These results suggest that the influence of FDI on value added productivity of their affiliates is significant in four high-tech sectors, while its impacts on quantity productivity of their affiliates are significant in only two sectors.

Since change in value added productivity may result from either change in output price or quantity or both, it is not clear whether FDI affects affiliates' output prices or production efficiency without contemplating quantity productivity. If ATT estimates are significant for value added productivity but insignificant for quantity, it can be inferred that, in those sectors, FDI increases the product prices of their affiliates rather than production efficiency. On the other hand, if ATT estimates are significant for only quantity productivity, it suggests the existence of the FDI direct effect on production efficiency of affiliates but not their prices.

The ATT estimation provides three main findings. First, FDI enhances production efficiency of affiliates/subsidiaries in the textile, chemical and chemical product, rubber and plastic product, and Furniture sectors, according to both, value added and physical output based productivity measures. Second, FDI increases value added productivity of affiliates, but not physical production efficiency, in basic metal, communication equipment and motor vehicle sectors. Third, FDI improves physical production efficiency of affiliates, but not value added productivity, in tanning leather, and electrical machinery.

4.5.2 A Parametric Control Function Based on Conditional Second Moments

Similar to the ATT approach, the set of covariates consists of the firm's age, the firm's market share, the firm's markup, firm's size dummies, an export dummy, an R&D dummy, the machinery age structure variable, year specifics and industry-specifics. One variable used in the control function approach that differs from ATT is the control variable which accounts for heterogeneity across firms. This variable is the novelty of Klein and Vella (2009).

Table 4.4 - 4.11 show the estimation results from this method. I estimate equation (4.2) with OLS and use the results from OLS with heteroskedastic standard errors as the baseline for comparison.

Like in the ATT estimation, two types of productivity have been employed to estimate the FDI effect with the Farre, Klein and Vella, hereafter FKV. Since the main objective in this chapter is to estimate the FDI direct effect, the analysis focuses on high-FDI sectors and two major production sectors that are not high-FDI.

The food and textile sectors, which are not high-FDI sectors, have positive and significant foreign share coefficients from FKV and OLS for both value added and quantity productivity. When comparing foreign share coefficients for value added productivity, FKV gives smaller coefficients for both the food and textile sectors. In contrast, considering quantity productivity, FKV provides smaller foreign share coefficients for the food sector but larger coefficient for the textile sector. The variables that capture firm heteroskedasticity are not significant in these sectors. These results suggest that foreign share level impacts the productivity of affiliates in both sectors.

In high-FDI sectors, it is anticipated that foreign share level will be positively correlated with the productivity of their affiliates, which means the higher foreign share the firm has, the more productive it is. From the ATT results, foreign firms in the chemical product and rubber and plastic product sectors are more productive than Thai firms. It turns out that when considering OLS results the coefficients of foreign share are insignificant for both value added and quantity productivity in these sectors, while FKV provides a negative and significant coefficient of foreign share for quantity productivity of the chemical product sector. This means the level of foreign share does not affect the productivity of affiliates in the Rubber and plastic product sector, but, in the chemical product sector, the higher the foreign share, the lower the quantity productivity the firms have. The estimates from OLS suggest no significant impact of foreign share level, but FKV provides one negatively significant in one case despite an insignificant control variable. This signifies heterogeneity across firms.

In the Fabricated metal sector, the ATT results indicate no productivity differences between foreign firms and Thai firms. The results from FKV suggest no difference in productivity among affiliates in this sector, while the OLS results imply the level of foreign share increases the quantity productivity of affiliates. In contrast, both FKV and OLS give negative and significant coefficients of foreign share for value added productivity, but give positive and significant coefficients for the quantity productivity in the Machinery sector. These results indicate that foreign shares have a negative relationship with prices but a positive relationship with the efficiency of firms in the Machinery sector. It can be inferred that in Machinery sector, the affiliates with higher foreign share have more efficient production technologies and thus charge lower prices.

The communication equipment and Motor vehicle sectors received the highest FDI inflows during the sample period, and the ATT results reflect that foreign firms are more productive than Thai firms in terms of value added. If the foreign share level has significant effects on the productivity of affiliates, the effects should be strong in these two sectors.

Consider the communication equipment sector; it turns out that the foreign share coefficient for value added from OLS estimation is insignificant, but it is positive and significant when estimating from FKV. In this case, the heteroskedastic control variable is negatively significant. However, both OLS and FKV provide positive and significant foreign share coefficients for quantity productivity. These results suggest that, when controlling for heteroskedasticity across firms, foreign share level raises product prices of affiliates and increases efficiency of affiliates regardless of the heteroskedastic control variable.

For the Motor vehicle sector, FKV and OLS provide consistent results for the foreign share coefficients in both value added and quantity productivity cases, but the coefficients from FKV are larger for value added productivity. The coefficients of foreign share are insignificant for value added productivity but significant for quantity productivity. It can be inferred that the level of foreign share does not significantly impact product prices but has substantial impacts on the efficiency of affiliates.

Overall, the coefficients of foreign share level from OLS are significant in six sectors for value added productivity and in nine sectors for quantity productivity. FKV provides significant coefficients of foreign share level in seven sectors for value added productivity and in nine sectors for quantity productivity.

4.6 Conclusions

The studies on foreign direct investment (FDI) effects in a host country have focused mainly on its spillover, or indirect effects although spillover is the byproduct of the direct effect due to FDI. If direct effects exist, then it is anticipated that other local firms may benefit from FDI as well. Before examining the spillover existence from FDI, the direct effect from FDI to the local affiliates should be explored. The objective of this chapter is to estimate the direct effect from FDI using firm-level data from manufacturing sectors in Thailand during 2001-2006.

The previous studies on FDI that included direct effect in the analysis did not correct for potential endogeneity due to unobserved factors that simultaneously determine productivity and FDI decisions. Most of empirical studies on FDI found insignificant FDI direct effects. To address the importance of direct effect from FDI, I applied two approaches to evaluate treatment effects: average treatment effect on the treated (ATT) based on propensity score matching proposed by Rosenbaum and Rubin (1983), and a parametric control function approach using conditional second moments proposed by Farre et al. (2010).

I draw several conclusions from these estimation results. First, we find evidence that FDI positively impacts the productivity in many industries according to a wide range of productivity measures. On the other hand, I also find that in several industries the impact of foreign ownership on productivity depends on the measure of productivity and for several industries I do not find foreign ownership effects at all. This suggests that attracting foreign investments to improve productivity seems a reasonable strategy for many industries, but future research is necessary to identify the source of the heterogeneity in the impact of FDI to refine policy recommendations. It is important to point out that even if we do not identify a positive impact of foreign ownership on productivity, FDI may still be beneficial for other reasons than enhancing a firm's productivity.

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Table 4.1: Variables Employed in Computing Propensity Scores

Sector	Matching Variables
15 Food	age, initial fund, export dummy, R&D dummy, % new machinery, markup, marketing cost
17 Textiles	age, marketing costs, R&D dummy, export dummy, %new machinery, %medium machinery, capital-labor ratio, markups
18 Wearing apparel	age, initial fund, ratio of domestic, export dummy, R&D dummy, %new machinery, %medium machinery
19 Tanning and dressing of leather	market share, ratio of domestic material costs, %new machinery, %medium machinery, markup capital-labor ratio, export dummy, R&D dummy
21 Paper and Paper products	age, intial fund, marketing costs, R&D dummy, export dummy, %new machinery, %medium machinery capital-labor ratio, markup, market share
22 Publishing and printing	age, initial fund, marketing costs, export dummy, R&D dummy, %new machinery, %medium machinery markup
24 Chemicals and chemical products	age, ratio of domestic material costs, export dummy, R&D dummy, %new machinery, %medium machinery
25 Rubber and plastic products	initial fund, market share, ratio of domestic material costs, export dummy, R&D dummy, markup capital-labor ratio, %new machinery, %medium machinery
26 Non-metallic mineral products	age, initial fund, export dummy, R&D dummy, %new machinery,
27 Basic metals	age, initial fund, ratio of domestic material costs, R&D dummy, export dummy, capital-labor ratio %medium machinery
28 Fabricated metal products	age, initial fund, market share, marketing costs, export dummy, R&D dummy, markup capital-labor ratio, %new machinery, %medium machinery
29 Machinery and equipment	initial fund, market share, ratio of domestic material costs, markup, %new machinery, %medium machinery
31 Electrical machinery	age, initial fund, %new machinery, %medium machinery, markup, export dummy, R&D dummy
32 Communication equipment	age, export dummy, R&D dummy, marketing costs, markup, %new machinery, ratio of domestic material costs
34 Motor vehicles	age, initial fund, ratio of domestic material costs, market share, export dummy, R&D dummy
36 Furniture	age, marketing costs, capital-labor ratio, export dummy, R&D dummy, markup, market share %new machinery

Table 4.2: Description of Variables Used in Propensity Score Estimation

Variable	Obs	Mean	Std. Dev.	Min	Max
log(market share)	8,095	-6.792648	2.214011	-19.85365	-.6975504
log(markup)	8,095	.2608364	.7620874	-14.00202	7.419073
log(age)	8,095	2.342938	.7516152	0	3.610918
Export dummy	8,095	.4552602	.498013	0	1
R&D dummy	8,095	.6599775	.4737341	0	1
Firm size dummy	8,095	.6509263	.4766952	0	1
log(% machine value age 0-3)	8,095	2.363873	1.65733	0	4.60517
log(%machine value age 4-6)	8,095	2.403362	1.566597	0	4.60517

Table 4.3: Average Treatment Effect on the Treated Based on Propensity Score Matching

Sector	ACF + De Loecker		Levinsohn & Petrin		LP + De Loecker		Local Obs	FDI Obs
	Value Added	Quantity	Value Added	Quantity	Value Added	Quantity		
15 Food	0.077	0.003	0.185	0.290	0.136	0.323	2,009	416
	(0.104)	(0.176)	(0.119)	(0.227)	(0.128)	(0.222)		
17 Textiles	0.345**	0.456**	0.659***	0.458	0.597***	0.505*	1,163	202
	(0.143)	(0.229)	(0.186)	(0.305)	(0.185)	(0.271)		
18 Wearing apparel	0.038	0.260*	-0.054	0.143	-0.054	0.185	829	188
	(0.091)	(0.157)	(0.159)	(0.243)	(0.157)	(0.238)		
19 Tanning and dressing of leather	0.396	0.749*	0.549**	1.455**	0.434*	0.892*	354	46
	(0.248)	(0.453)	(0.263)	(0.607)	(0.244)	(0.482)		
21 Paper and Paper products	0.065	-0.178	0.567	-0.158	0.035	-0.378	401	85
	(0.177)	(0.263)	(0.375)	(0.334)	(0.169)	(0.314)		
22 Publishing and printing	0.140	-0.276	0.208	-0.517	0.166	-0.506	475	51
	(0.224)	(0.380)	(0.252)	(0.362)	(0.215)	(0.352)		
24 Chemicals and	0.460***	0.546**	0.367**	1.999***	0.586***	0.748**	591	346
chemical products	(0.162)	(0.252)	(0.181)	(0.451)	(0.202)	(0.314)		
25 Rubber and plastic products	0.125**	0.501**	0.402***	0.920***	0.287**	0.663***	1,141	330
	(0.060)	(0.230)	(0.135)	(0.314)	(0.122)	(0.264)		
26 Non-metallic mineral products	0.065	-0.310	0.475	1.509	0.552	1.068	1,110	142
	(0.397)	(0.895)	(0.883)	(1.232)	(0.618)	(1.027)		
27 Basic metals	0.447***	0.8799	1.008**	0.679	1.191***	0.747	283	85
	(0.139)	(0.782)	(0.414)	(0.861)	(0.441)	(0.944)		
28 Fabricated metal products	0.179	0.852	0.945***	2.389***	0.844***	2.500***	485	208
	(0.237)	(0.837)	(0.276)	(0.767)	(0.242)	(0.690)		
29 Machinery and equipment	-0.133	0.043	-0.009	0.589	0.016	0.648	491	243
	(0.139)	(0.710)	(0.158)	(1.114)	(0.158)	(1.038)		
31 Electrical machinery	0.014	0.855*	1.146***	1.597***	0.338**	1.263**	323	177
and apparatus	(0.113)	(0.510)	(0.172)	(0.623)	(0.165)	(0.608)		
32 Communication equipment	0.270**	-0.191	-0.181	-1.393***	-0.142	-1.518***	245	385
and apparatus	(0.113)	(0.450)	(0.161)	(0.548)	(0.145)	(0.531)		
34 Motor vehicles	0.522***	0.477	0.737***	0.863	0.771***	-0.586	260	161
	(0.168)	(0.553)	(0.154)	(0.552)	(0.181)	(0.529)		
36 Furniture	0.254**	0.833**	0.306*	0.866*	0.330	0.667*	528	261
	(0.121)	(0.386)	(0.172)	(0.478)	(0.210)	(0.402)		

Table 4.4: FDI Direct Effect using FKV Method of ISIC 15, 17

Sectors	Food and Beverage (ISIC 15)				Textiles (ISIC 17)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	0.384***	0.326***	0.798***	0.566***	0.378***	0.333**	0.569**	0.792**
	(0.0833)	(0.0971)	(0.198)	(0.170)	(0.115)	(0.143)	(0.223)	(0.307)
weight		3.49e-05		6.70e-05		5.39e-05		-0.00113
		(5.81e-05)		(4.39e-05)		(0.000178)		(0.000824)
lnmarkup	0.0990***	0.105***	0.123***	0.122***	0.157***	0.184***	0.154***	0.158***
	(0.0137)	(0.0143)	(0.0248)	(0.0245)	(0.0183)	(0.0258)	(0.0420)	(0.0424)
lnmktsh	-0.138***	-0.130***	-0.341***	-0.344***	-0.378***	-0.276***	-1.201***	-1.201***
	(0.0349)	(0.0336)	(0.0878)	(0.0874)	(0.0478)	(0.104)	(0.190)	(0.191)
lnage	-0.0292	-0.0376	0.159***	0.141***	-0.0836**	-0.110***	-0.0225	-0.0182
	(0.0287)	(0.0301)	(0.0509)	(0.0492)	(0.0340)	(0.0363)	(0.0752)	(0.0756)
exportstatus	-0.369***	-0.378***	-0.696***	-0.649***	-0.189***	-0.251***	-0.661***	-0.681***
	(0.0493)	(0.0508)	(0.106)	(0.108)	(0.0565)	(0.0695)	(0.147)	(0.148)
rdexpense	-0.127	-0.140*	-0.327**	-0.336**	0.0250	0.0417	-0.307	-0.315
	(0.0773)	(0.0783)	(0.137)	(0.137)	(0.0890)	(0.109)	(0.223)	(0.222)
size2	0.196***	0.206***	0.382***	0.359***	-0.103**	-0.0582	0.225*	0.235*
	(0.0471)	(0.0485)	(0.0783)	(0.0783)	(0.0506)	(0.0578)	(0.121)	(0.122)
k1	-0.00184	-0.00948	0.0708***	0.0662***	0.00241	-0.0111	-0.0493	-0.0510
	(0.0151)	(0.0159)	(0.0260)	(0.0255)	(0.0151)	(0.0167)	(0.0351)	(0.0350)
k3	-0.0136	-0.00537	0.0144	0.0122	-0.0319**	-0.0325*	-0.0832**	-0.0858***
	(0.0132)	(0.0138)	(0.0252)	(0.0250)	(0.0156)	(0.0168)	(0.0330)	(0.0327)
isicdum1	-0.555***	-0.563***	-1.757***	-1.759***	-0.164	0.152	2.328***	2.300***
	(0.169)	(0.169)	(0.341)	(0.340)	(0.144)	(0.173)	(0.427)	(0.430)
isicdum2	-0.590***	-0.592***	-1.762***	-1.754***	-0.170	0.130	1.895***	1.885***
	(0.160)	(0.161)	(0.340)	(0.339)	(0.158)	(0.193)	(0.458)	(0.459)
isicdum3	-0.846***	-0.846***	-2.083***	-2.059***	-0.280*	0.0175	1.423***	1.421***
	(0.161)	(0.162)	(0.348)	(0.348)	(0.158)	(0.199)	(0.451)	(0.453)
isicdum4	0.612***	0.630***	0.732**	0.745**	0.117	0.367*	2.153***	2.134***
	(0.169)	(0.170)	(0.346)	(0.345)	(0.169)	(0.192)	(0.468)	(0.470)
isicdum5	-0.178	-0.185	-1.721***	-1.793***	0.171	0.465**	1.717***	1.694***
	(0.171)	(0.174)	(0.357)	(0.365)	(0.157)	(0.181)	(0.477)	(0.480)
isicdum6	-0.707***	-0.702***	-2.133***	-2.124***				
	(0.160)	(0.161)	(0.364)	(0.362)				
Constant	12.01***	12.12***	7.380***	7.821***	13.84***	13.76***	8.493***	8.532***
	(0.240)	(0.240)	(0.472)	(0.450)	(0.212)	(0.288)	(0.630)	(0.633)
Observations	1,342	1,359	1,342	1,342	658	682	658	658
R-squared	0.388	0.389	0.503	0.506	0.299	0.238	0.318	0.319

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.5: FDI Direct Effect using FKV Method of ISIC 18, 19

Sector	Wearing Apparel (ISIC 18)				Tanning Leather (ISIC 19)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	0.0255	0.198	0.155	0.394	0.243*	0.227	0.601*	0.762**
	(0.124)	(0.206)	(0.194)	(0.335)	(0.146)	(0.166)	(0.312)	(0.313)
weight		-0.0639		-0.000915		-1.92e-05		-0.000165
		(0.0688)		(0.00102)		(0.000146)		(0.000204)
lnmarkup	0.0543**	0.0500**	0.0253	0.0188	0.0259	0.0290	-0.0644	-0.0702
	(0.0219)	(0.0229)	(0.0335)	(0.0340)	(0.0337)	(0.0344)	(0.0672)	(0.0675)
lnmktsh	-0.129**	-0.123**	-0.570***	-0.564***	-0.293**	-0.311**	-0.580***	-0.602***
	(0.0566)	(0.0574)	(0.0611)	(0.0610)	(0.123)	(0.131)	(0.175)	(0.168)
lnage	-0.111***	-0.104***	-0.133***	-0.125***	0.155**	0.170**	0.296**	0.272**
	(0.0372)	(0.0387)	(0.0463)	(0.0464)	(0.0754)	(0.0759)	(0.134)	(0.135)
exportstatus	-0.105*	-0.108*	-0.168*	-0.177*	-0.0187	-0.0683	0.134	0.134
	(0.0603)	(0.0597)	(0.0945)	(0.0945)	(0.169)	(0.161)	(0.234)	(0.237)
rdexpense	-0.0703	-0.0798	0.0742	0.0780	-0.359	-0.368*	-0.352	-0.361
	(0.113)	(0.111)	(0.176)	(0.170)	(0.221)	(0.221)	(0.348)	(0.349)
size2	0.00875	-0.00483	0.00778	-0.0169	-0.286**	-0.291**	0.0489	0.0496
	(0.0620)	(0.0632)	(0.0882)	(0.0917)	(0.116)	(0.115)	(0.203)	(0.204)
k1	-0.000887	-0.000510	-0.0225	-0.0236	-0.0526	-0.0549	-0.0387	-0.0431
	(0.0200)	(0.0199)	(0.0268)	(0.0270)	(0.0437)	(0.0415)	(0.0579)	(0.0572)
k3	0.0245	0.0219	0.0244	0.0203	0.104***	0.107***	-0.00287	-0.00367
	(0.0201)	(0.0197)	(0.0294)	(0.0295)	(0.0364)	(0.0357)	(0.0605)	(0.0594)
isicdum1						0.693***		1.873***
						(0.144)		(0.287)
isicdum2					-0.878***	-0.224*	-1.708***	0.182
					(0.155)	(0.132)	(0.215)	(0.270)
isicdum3					-0.635***		-1.772***	
					(0.136)		(0.283)	
Constant	10.25***	10.08***	7.475***	7.432***	11.78***	10.88***	5.972***	4.163***
	(0.258)	(0.247)	(0.376)	(0.372)	(0.386)	(0.352)	(0.794)	(0.802)
Observations	439	440	439	439	201	205	201	201
R-squared	0.058	0.060	0.291	0.293	0.330	0.346	0.372	0.375

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.6: FDI Direct Effect using FKV Method of ISIC 21, 22

Sector	Paper and Paper Products (ISIC 21)				Publishing and Printing (ISIC 22)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	-0.0611	0.0922	-0.0984	0.278	-0.00700	0.939**	-0.792	-0.798
	(0.240)	(0.314)	(0.315)	(0.340)	(0.415)	(0.404)	(0.705)	(0.718)
weight		-0.000149		-0.000260**		-4.38e-05***		3.74e-05
		(0.000205)		(0.000118)		(8.54e-06)		(0.000126)
lnmarkup	0.0388	0.0212	0.182***	0.197***	0.212***	0.168***	0.100	0.100
	(0.0335)	(0.0311)	(0.0658)	(0.0651)	(0.0486)	(0.0493)	(0.0680)	(0.0686)
lnmktsh	-0.0322	-0.0399	-0.373**	-0.385**	-0.356***	-0.271**	-0.279**	-0.280**
	(0.0947)	(0.0952)	(0.182)	(0.183)	(0.108)	(0.110)	(0.128)	(0.130)
lnage	-0.0242	-0.0184	0.0609	0.0394	0.0887*	0.120**	0.0614	0.0606
	(0.0499)	(0.0491)	(0.126)	(0.124)	(0.0516)	(0.0535)	(0.119)	(0.121)
exportstatus	-0.245**	-0.325***	-0.507**	-0.575***	-0.0980	0.0364	-0.583**	-0.586**
	(0.113)	(0.113)	(0.216)	(0.219)	(0.151)	(0.150)	(0.266)	(0.274)
rdexpense	-0.187	-0.158	-0.330	-0.299	0.107	0.232	0.646*	0.647*
	(0.180)	(0.176)	(0.642)	(0.639)	(0.259)	(0.215)	(0.366)	(0.368)
size2	-0.00112	-0.0649	-0.0327	-0.0830	-0.159	-0.199**	0.110	0.113
	(0.0869)	(0.0814)	(0.156)	(0.158)	(0.0965)	(0.0925)	(0.196)	(0.200)
k1	0.00815	0.00577	0.0575	0.0525	-0.0840**	-0.0654*	0.00507	0.00521
	(0.0242)	(0.0239)	(0.0465)	(0.0458)	(0.0371)	(0.0363)	(0.0547)	(0.0548)
k3	-0.0505	-0.0424	0.00646	-0.000392	-0.00855	-0.0203	0.0396	0.0396
	(0.0313)	(0.0300)	(0.0502)	(0.0498)	(0.0335)	(0.0321)	(0.0533)	(0.0535)
isicdum1		0.269**						
		(0.104)						
isicdum2	-0.191*	0.0460	-0.389**	-0.396**				
	(0.102)	(0.106)	(0.196)	(0.196)				
isicdum3	-0.296***		0.0945	0.0933				
	(0.107)		(0.242)	(0.240)				
Constant	11.51***	10.50***	7.605***	7.742***	14.50***	13.86***	8.253***	8.255***
	(0.314)	(0.260)	(0.712)	(0.697)	(0.506)	(0.422)	(0.704)	(0.707)
Observations	242	253	242	242	225	248	225	225
R-squared	0.170	0.177	0.123	0.133	0.219	0.210	0.096	0.096

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.7: FDI Direct Effect using FKV Method of ISIC 24, 25

Sector	Chemicals and Chemical Products (ISIC 24)				Rubber and Plastic Products (ISIC 25)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	-0.145	-0.137	-0.224	-0.376*	-0.102	-0.0899	-0.275	-0.240
	(0.123)	(0.150)	(0.168)	(0.214)	(0.0658)	(0.0832)	(0.199)	(0.221)
weight		5.51e-07		0.00103		0.00116		-7.94e-05
		(8.90e-05)		(0.000775)		(0.00224)		(0.000163)
lnmarkup	0.167***	0.163***	0.220***	0.221***	0.188***	0.164***	0.351***	0.352***
	(0.0299)	(0.0297)	(0.0484)	(0.0484)	(0.0132)	(0.0159)	(0.0386)	(0.0389)
lnmktsh	-0.200***	-0.197***	-0.511***	-0.512***	-0.334***	-0.276***	-1.281***	-1.292***
	(0.0422)	(0.0418)	(0.107)	(0.107)	(0.0696)	(0.0720)	(0.122)	(0.127)
lnage	-0.0998*	-0.0964	0.203**	0.195**	-0.0350	0.00527	0.165**	0.165**
	(0.0596)	(0.0598)	(0.0943)	(0.0954)	(0.0223)	(0.0256)	(0.0841)	(0.0841)
exportstatus	0.105	0.0932	-0.0825	-0.0437	-0.0756*	-0.0708*	-0.264*	-0.269*
	(0.0846)	(0.0881)	(0.123)	(0.127)	(0.0403)	(0.0415)	(0.141)	(0.142)
rdexpense	0.112	0.120	-0.368*	-0.365	-0.0519	-0.0275	-0.196	-0.196
	(0.157)	(0.158)	(0.223)	(0.224)	(0.0837)	(0.0873)	(0.230)	(0.230)
size2	0.0149	0.00864	0.124	0.108	0.0371	0.0225	0.115	0.116
	(0.0917)	(0.0924)	(0.150)	(0.152)	(0.0397)	(0.0470)	(0.126)	(0.127)
k1	-0.0373	-0.0371	-0.0283	-0.0214	-0.0316***	-0.0453***	0.126***	0.125***
	(0.0244)	(0.0251)	(0.0339)	(0.0346)	(0.0115)	(0.0127)	(0.0425)	(0.0426)
k3	-0.0343	-0.0351	0.0703*	0.0668*	0.000187	-0.0111	-0.0412	-0.0413
	(0.0297)	(0.0299)	(0.0364)	(0.0365)	(0.0122)	(0.0135)	(0.0398)	(0.0398)
isicdum1	0.233	0.222	0.583***	0.542**		0.150**		
	(0.170)	(0.171)	(0.206)	(0.210)		(0.0610)		
isicdum2	0.678***	0.671***	0.591***	0.569***	0.0160	0.186***	-0.408***	-0.404***
	(0.151)	(0.152)	(0.185)	(0.187)	(0.0381)	(0.0568)	(0.124)	(0.125)
isicdum3	0.416***	0.406***	-0.409*	-0.430**	-0.102*		-3.327***	-3.317***
	(0.152)	(0.153)	(0.212)	(0.214)	(0.0563)		(0.183)	(0.186)
isicdum4	-0.204	-0.204	-1.322***	-1.366***				
	(0.159)	(0.160)	(0.221)	(0.229)				
isicdum5	-0.0688	-0.0902	-0.566**	-0.621**				
	(0.169)	(0.173)	(0.245)	(0.250)				
isicdum6	-0.236	-0.224	0.575	0.522				
	(0.640)	(0.640)	(1.191)	(1.196)				
Constant	9.758***	9.663***	5.793***	5.872***	11.26***	10.89***	11.56***	11.57***
	(0.348)	(0.372)	(0.471)	(0.480)	(0.166)	(0.190)	(0.529)	(0.530)
Observations	466	470	466	466	714	727	714	714
R-squared	0.305	0.302	0.362	0.363	0.371	0.268	0.441	0.441

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.8: FDI Direct Effect using FKV Method of ISIC 26, 27

Sector	Non-Metallic Mineral Products (ISIC 26)				Basic Metals (ISIC 27)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	0.155	0.119	0.502	0.212	0.364**	0.775***	-1.707**	-2.689***
	(0.121)	(0.135)	(0.514)	(0.586)	(0.160)	(0.174)	(0.683)	(0.959)
weight		0.000118		0.000791*		-0.00336***		0.0304**
		(0.000177)		(0.000418)		(0.000989)		(0.0153)
lnmarkup	0.190***	0.190***	-0.135**	-0.141**	0.306***	0.228***	1.132***	1.183***
	(0.0161)	(0.0162)	(0.0623)	(0.0625)	(0.0321)	(0.0429)	(0.105)	(0.109)
lnmktsh	-0.246***	-0.246***	-0.195	-0.189	-0.345***	-0.226***	-2.274***	-2.349***
	(0.0497)	(0.0500)	(0.191)	(0.192)	(0.0483)	(0.0625)	(0.372)	(0.355)
lnage	-0.101**	-0.102**	-0.0463	-0.0562	0.0214	0.0806	0.321	0.219
	(0.0426)	(0.0429)	(0.136)	(0.136)	(0.0652)	(0.0834)	(0.231)	(0.242)
exportstatus	-0.123	-0.118	0.641**	0.676**	-0.0374	-0.0571	-1.328***	-1.348***
	(0.0795)	(0.0797)	(0.288)	(0.292)	(0.0806)	(0.0816)	(0.340)	(0.342)
rdexpense	-0.0751	-0.0720	-0.813	-0.788	0.201	0.253**	-1.335*	-1.386*
	(0.127)	(0.127)	(0.500)	(0.501)	(0.129)	(0.119)	(0.805)	(0.792)
size2	0.0154	0.0123	-0.269	-0.295	0.365***	0.373***	1.457***	1.330***
	(0.0536)	(0.0541)	(0.219)	(0.222)	(0.0930)	(0.104)	(0.336)	(0.343)
k1	-0.0419**	-0.0417**	-0.0920	-0.0907	0.0228	0.0193	-0.159*	-0.132
	(0.0172)	(0.0172)	(0.0784)	(0.0788)	(0.0293)	(0.0299)	(0.0859)	(0.0851)
k3	0.00802	0.00797	0.0917	0.0915	-0.0449	-0.0540*	-0.0445	-0.0517
	(0.0174)	(0.0174)	(0.0784)	(0.0787)	(0.0307)	(0.0322)	(0.0972)	(0.0972)
isicdum1	-1.581***	-1.570***	-4.674***	-4.587***	0.447***	-0.0432	0.430	-0.0594
	(0.122)	(0.125)	(0.495)	(0.506)	(0.0999)	(0.212)	(0.534)	(0.635)
isicdum2	2.581***	2.583***	4.309***	4.325***		-0.812***		
	(0.115)	(0.115)	(0.367)	(0.361)		(0.235)		
isicdum3	-0.695***	-0.691***	-1.969***	-1.941***	0.546**		0.708	0.375
	(0.148)	(0.148)	(0.582)	(0.578)	(0.214)		(0.597)	(0.654)
isicdum4	-0.230	-0.217	1.566***	1.672***				
	(0.214)	(0.215)	(0.581)	(0.586)				
isicdum5	2.831***	2.837***	2.143***	2.190***				
	(0.118)	(0.118)	(0.401)	(0.398)				
Constant	10.84***	10.84***	2.959***	2.941***	11.89***	12.04***	12.43***	13.49***
	(0.241)	(0.241)	(0.839)	(0.831)	(0.295)	(0.377)	(1.110)	(1.318)
Observations	567	567	567	567	174	180	174	174
R-squared	0.891	0.891	0.599	0.600	0.508	0.413	0.527	0.534

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.9: FDI Direct Effect using FKV Method of ISIC 28, 29

Sector	Fabricated Metal Products (ISIC 28)				Machinery and Equipment (ISIC 29)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	0.225	0.0109	1.298*	0.760	-0.452***	-0.539***	1.506***	1.516**
	(0.157)	(0.170)	(0.734)	(0.860)	(0.166)	(0.170)	(0.566)	(0.589)
weight		0.00528		9.78e-05		0.000140		-4.32e-06
		(0.00330)		(7.20e-05)		(0.000232)		(0.000132)
lnmarkup	0.447***	0.452***	0.205	0.218	0.0791*	0.0720*	0.0448	0.0453
	(0.0441)	(0.0437)	(0.216)	(0.214)	(0.0419)	(0.0434)	(0.119)	(0.123)
lnmktsh	-0.482***	-0.476***	-0.601	-0.555	0.175	0.176	0.363	0.364
	(0.0519)	(0.0526)	(0.382)	(0.386)	(0.227)	(0.230)	(0.234)	(0.233)
lnage	0.161***	0.174***	0.514	0.597	-0.0984*	-0.172***	0.376	0.376
	(0.0602)	(0.0575)	(0.457)	(0.443)	(0.0520)	(0.0638)	(0.255)	(0.256)
exportstatus	-0.00557	0.0223	0.844	0.964	-0.250**	-0.245**	-0.236	-0.239
	(0.132)	(0.128)	(0.737)	(0.752)	(0.113)	(0.124)	(0.446)	(0.459)
rdexpense	0.306	0.271	-1.621	-1.674	0.192	0.191	-1.707***	-1.705***
	(0.186)	(0.186)	(1.007)	(1.017)	(0.193)	(0.199)	(0.573)	(0.570)
size2	0.00303	-0.0167	-0.132	-0.160	-0.189*	-0.245**	0.486	0.488
	(0.126)	(0.121)	(0.582)	(0.581)	(0.111)	(0.123)	(0.394)	(0.407)
k1	0.0112	0.0159	0.299	0.325	-0.0898**	-0.105***	0.0840	0.0832
	(0.0339)	(0.0344)	(0.202)	(0.198)	(0.0355)	(0.0345)	(0.121)	(0.123)
k3	-0.0876**	-0.0765**	0.0491	0.101	-0.0790**	-0.103***	0.0195	0.0192
	(0.0368)	(0.0365)	(0.205)	(0.198)	(0.0346)	(0.0337)	(0.113)	(0.114)
isicdum1	0.466	0.430	-0.836	-0.995	-0.990***	-1.369***	5.371***	3.803***
	(0.347)	(0.266)	(1.158)	(1.167)	(0.220)	(0.457)	(0.675)	(0.792)
isicdum2		-0.00517			-0.519*	-0.938***	6.071***	4.503***
		(0.380)			(0.280)	(0.263)	(0.778)	(0.810)
isicdum3	0.0323	0.0329	0.462	0.476	-0.670***	-1.094***	8.638***	7.073***
	(0.331)	(0.218)	(0.953)	(0.956)	(0.246)	(0.352)	(0.787)	(0.699)
isicdum4	-0.0671	-0.0169	-3.656***	-3.539***	-0.760***	-1.178***	3.124***	1.557
	(0.348)	(0.202)	(1.262)	(1.242)	(0.243)	(0.439)	(1.011)	(1.238)
isicdum5					-0.765***	-1.165**	3.845***	2.276**
					(0.252)	(0.507)	(0.872)	(0.930)
isicdum6					-0.441**	-0.859**	6.102***	4.533***
					(0.196)	(0.349)	(0.602)	(0.707)
Constant	14.48***	14.55***	2.610	2.549	10.50***	11.17***	-4.926***	-3.354*
	(0.471)	(0.441)	(1.836)	(1.810)	(0.406)	(0.581)	(1.539)	(1.891)
Observations	166	167	166	166	350	354	350	350
R-squared	0.641	0.649	0.305	0.314	0.194	0.232	0.261	0.261

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.10: FDI Direct Effect using FKV Method of ISIC 31, 32

Sector	Electrical Machinery (ISIC 31)				Communication Equipment (ISIC 32)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	-0.283**	-0.384**	-0.156	-1.017	0.0357	0.463**	1.082**	1.540**
	(0.130)	(0.165)	(0.580)	(0.725)	(0.105)	(0.191)	(0.499)	(0.673)
weight		0.000580		0.00154		-0.00438**		-0.000283
		(0.000645)		(0.000987)		(0.00188)		(0.000313)
lnmarkup	0.243***	0.232***	0.291**	0.318***	0.0993***	0.0976***	-0.347**	-0.334**
	(0.0230)	(0.0239)	(0.116)	(0.119)	(0.0288)	(0.0295)	(0.135)	(0.137)
lnmktsh	-0.255***	-0.243***	-1.046***	-1.095***	-0.0267	-0.0314	0.154	0.158
	(0.0302)	(0.0343)	(0.287)	(0.281)	(0.0953)	(0.0854)	(0.595)	(0.590)
lnage	-0.152**	-0.151**	-0.203	-0.294*	0.0253	0.0242	-0.238	-0.238
	(0.0661)	(0.0659)	(0.185)	(0.174)	(0.0623)	(0.0616)	(0.312)	(0.311)
exportstatus	0.0442	0.0807	0.766*	1.082***	0.162	-0.0597	-0.519	-0.639
	(0.0936)	(0.104)	(0.414)	(0.411)	(0.115)	(0.134)	(0.669)	(0.671)
rdexpense	-0.171	-0.113	1.001*	1.089*	0.0748	0.0870	-1.910***	-1.786**
	(0.112)	(0.118)	(0.599)	(0.583)	(0.196)	(0.195)	(0.697)	(0.716)
size2	0.00208	-0.0492	-0.00832	-0.0741	0.149*	0.217**	-0.754*	-0.677
	(0.0667)	(0.0683)	(0.306)	(0.302)	(0.0815)	(0.0854)	(0.438)	(0.431)
k1	-0.0626***	-0.0755***	0.0509	0.0321	0.0656**	0.0696**	-0.178	-0.170
	(0.0228)	(0.0234)	(0.109)	(0.106)	(0.0285)	(0.0276)	(0.139)	(0.137)
k3	0.0235	0.0302	-0.258**	-0.246**	-0.0498	-0.0576*	0.390**	0.384**
	(0.0227)	(0.0228)	(0.107)	(0.106)	(0.0338)	(0.0325)	(0.155)	(0.155)
isicdum1	0.350***	-0.140	-0.966*	-1.060*	0.562***	0.676***	0.693	0.859
	(0.116)	(0.0944)	(0.553)	(0.555)	(0.130)	(0.135)	(0.668)	(0.703)
isicdum2	0.504***	0.0414	-0.726	-0.733	0.668***	0.765***	1.033	1.237*
	(0.125)	(0.116)	(0.631)	(0.648)	(0.135)	(0.147)	(0.651)	(0.714)
isicdum3	0.549***	0.0407	1.011*	1.023*				
	(0.125)	(0.105)	(0.545)	(0.550)				
isicdum4		-0.448***						
		(0.120)						
isicdum5	0.137	-0.344***	0.676	0.534				
	(0.108)	(0.103)	(0.542)	(0.553)				
isicdum6	0.492***		0.681	0.791				
	(0.117)		(0.726)	(0.722)				
Constant	13.37***	13.86***	10.72***	11.34***	13.94***	13.90***	4.720**	4.560**
	(0.340)	(0.365)	(1.243)	(1.246)	(0.414)	(0.407)	(1.871)	(1.869)
Observations	237	246	237	237	224	233	224	224
R-squared	0.505	0.487	0.352	0.372	0.190	0.179	0.120	0.123

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Table 4.11: FDI Direct Effect using FKV Method of ISIC 34, 36

Sector	Motor Vehicles (ISIC 34)				Furniture (ISIC 36)			
TFP	Value Added		Quantity		Value Added		Quantity	
Variables	OLS	FKV	OLS	FKV	OLS	FKV	OLS	FKV
fdishare	0.0334	0.389	1.338***	1.222**	0.203	-0.171	1.453***	2.510***
	(0.176)	(0.337)	(0.508)	(0.597)	(0.147)	(0.190)	(0.340)	(0.669)
weight		-0.0123		2.39e-05		0.000752*		-0.0155**
		(0.0138)		(4.40e-05)		(0.000383)		(0.00773)
lnmarkup	0.269***	0.291***	0.187	0.189	0.0826**	0.0950***	0.216**	0.188*
	(0.0508)	(0.0565)	(0.151)	(0.151)	(0.0322)	(0.0320)	(0.100)	(0.100)
lnmktsh	-0.361***	-0.117	0.135	0.118	-0.0334	-0.0313	-0.263	-0.270
	(0.103)	(0.128)	(0.337)	(0.344)	(0.0855)	(0.0827)	(0.282)	(0.282)
lnage	-0.154	-0.158	0.213	0.208	-0.0388	-0.0513	-0.554***	-0.528***
	(0.0997)	(0.112)	(0.258)	(0.260)	(0.0633)	(0.0593)	(0.189)	(0.191)
exportstatus	-0.0457	-0.270*	0.566	0.576	-0.108	-0.121	0.0186	0.0507
	(0.127)	(0.163)	(0.411)	(0.414)	(0.120)	(0.122)	(0.438)	(0.435)
rdexpense	-0.357	-0.290	0.214	0.214	-0.111	-0.0974	0.716	0.687
	(0.246)	(0.264)	(0.866)	(0.868)	(0.227)	(0.221)	(0.580)	(0.577)
size2	-0.0409	-0.0228	2.139***	2.111***	0.0585	0.135	0.182	-0.0142
	(0.129)	(0.144)	(0.398)	(0.407)	(0.103)	(0.107)	(0.335)	(0.359)
k1	-0.136***	-0.167***	0.306**	0.314**	0.0293	0.0338	0.0884	0.0760
	(0.0443)	(0.0507)	(0.150)	(0.153)	(0.0292)	(0.0290)	(0.0901)	(0.0874)
k3	-0.0353	-0.0598	-0.441***	-0.442***	0.0742***	0.0719**	0.0909	0.0953
	(0.0512)	(0.0563)	(0.134)	(0.135)	(0.0280)	(0.0278)	(0.0728)	(0.0738)
isicdum1	-0.0981	-0.476	2.944***	2.983***	0.336	0.266	-1.787***	-1.615***
	(0.308)	(0.329)	(0.935)	(0.943)	(0.234)	(0.240)	(0.476)	(0.489)
isicdum2	-0.655***	-0.746***	5.156***	5.151***	0.420*	0.378	-0.771	-0.717
	(0.233)	(0.239)	(0.747)	(0.747)	(0.246)	(0.245)	(0.517)	(0.519)
isicdum3					0.416*	0.407*	0.603	0.610
					(0.242)	(0.246)	(0.518)	(0.514)
Constant	11.27***	11.75***	1.546	1.591	10.85***	11.00***	10.71***	10.38***
	(0.567)	(0.692)	(1.540)	(1.545)	(0.467)	(0.460)	(1.273)	(1.277)
Observations	176	184	176	176	270	271	270	270
R-squared	0.325	0.285	0.544	0.545	0.154	0.174	0.333	0.343

Note: i) Standard errors are in parentheses. ii) The standard errors are clustered based on industry-year.

iii) k1 = %machinery age 0-3 years to total value of machinery, k3 = %machinery age 7 years and above to total value of machinery

iv) size2 equals 1 if firms are medium size and equals 0 otherwise

Chapter 5

Does Foreign Ownership Improve the Productivity of Locally Owned Firms?

5.1 Introduction

Foreign direct investment (FDI) is considered as an external source of technology advancement that may improve overall productivity of host countries. The benefits from FDI inflows are that foreign owners transfer technological and managerial knowledge to their local affiliates and subsidiaries and potentially the knowledge spills over to locally owned firms. As a result the overall productivity of a country improves, not only because of the direct impact of FDI, but also due to spillover effects from foreign owned to locally owned firms. These potential benefits have brought about intense competition among countries, especially developing countries, to attract FDI inflows. However, there is no guarantee that spillover from foreign owned to domestically owned firms exists. The high price but uncertain return from FDI therefore raises the question whether the effort to attract FDI is worthwhile. In this chapter I examine if locally owned firms benefit in terms of their productivity from spillover effects.

There are no existing comprehensive theoretical models that predict whether or not the knowledge from FDI will be transmitted to other local firms in the host countries, because there are several determinant factors that vary across countries and industries. Moreover these determinant factors may also vary across regions in each country due to geographical diversity.[31]

To my knowledge, there is no empirical study that examines the impact of geography on vertical and horizontal spillover effects.[32] However, empirical evidence indicates that there is a strong relationship between agglomeration and FDI inflows.[33] Krugman (1979) shows that it is optimal for firms to locate close to each other because of externalities. But, because spillover effects are an externality, geographical space may be an important determinant of technological spillover driven by FDI.

[31] See more discussion on FDI spillovers determinant factors in Crespo and Fontoura (2007) and on the role of geography on FDI in Jordaan (2009)

[32] Jordaan (2011) examine the relationship between geography and horizontal spillover effects. See Jordaan (2009)) and Crespo and Fontoura (2007) for literature surveys.

[33] See Crozet et al. (2004) and Bronzini (2007).

In this chapter, I examine productivity spillover effects to locally owned firms in a developing economy. I use firm-level data from the manufacturing sector of Thailand and the productivity estimates from Chapter 3.[34] Thailand is one of the developing countries that have received a large share of FDI inflows. Investment policies in Thailand were relaxed continuously since the financial crisis in 1997-1998. In addition, the Thai government spent enormous sums for industrial estates and infrastructure development in order to attract FDI inflows. However, there is no empirical work that examine the impact of these FDI inflows on productivity of local affiliates and the spillover of productivity from foreign owned to locally owned firms in Thailand.

The main focus in this chapter is the FDI spillover through horizontal and vertical relationships accounting for the contribution of agglomeration and geography. I modify the estimation strategy by Javorcik (2004) and introduce agglomeration-spatial weights to spillover variables. This approach captures the contribution of firm clusters and distance between firms on spillover effects. To do this, I combine distance information and firm clusters with the input/output shares along supply chains. The correlation between geographical space, firm clusters and input/output shares is important because the closer proximity between foreign firms and local supplier/buyer clusters, the more spillovers may be absorbed. Moreover, I extend Javorcik's models by adding lagged terms of spillover variables and export and R&D dummy variables as suggested by Keller and Yeaple (2009), because the transmission process of technological knowledge may take some time and exporters and R&D expenditure potentially contribute to productivity.

The results from the baseline specification without controlling for agglomeration and distance contradict the results from the existing literature. However, when controlling for agglomeration and distance, the results are consistent with the previous literature.[35] This suggests that the underlying transmission of productivity in Thailand depends on agglomeration and geographical space. Thai firms benefit from FDI through backward linkages, while FDI reduces productivity of Thai

[34] See data details in Chapter 2.

[35] Blalock and Gertler (2008); Javorcik (2004); Liu (2008) found positive FDI spillovers through backward linkages.

firms through forward linkages and horizontal channels. This reflects that FDI inflows to buyer sectors benefit Thai firms, while FDI inflows to supplier sectors and to competitor firms worsen performance of Thai firms. Surprisingly, FDI spillovers do not exist in high-FDI sectors while they are apparent in low-FDI sectors.

In the next section, I review some existing literature on FDI spillovers for developing countries as well as agglomeration and geography impacts on FDI inflows. Section 5.3 provides the details of the empirical specifications. Section 5.4, describes the data. Variable construction strategies are given in section 5.5. Section 5.6 provides the estimation results and section 5.7 concludes.

5.2 Literature

Previous studies employing firm-level data from developing countries find mixed results for FDI spillovers through horizontal relationships. For example, Haddad and Harrison (1993) with Moroccan data and Aitken and Harrison (1999) with Venezuelan data, consider only spillover through horizontal relationships. Both find negative spillovers to domestic rivals in the same industry. In contrast, Kathuria (2002) finds positive spillovers in high-tech industries but negative spillovers in low-tech industries for firms in India. Suyanto et al. (2009) uses data of the chemical and pharmaceutical industries in Indonesia and finds positive spillover effects.

These studies employ various productivity measures. Kathuria (2002) and Suyanto et al. (2009) estimate productivity with a stochastic frontier approach and they both find positive spillovers in high-tech sectors. Haddad and Harrison (1993) estimate productivity by assuming time invariant productivity, while Aitken and Harrison (1999) use log level of output. All these studies did not correct for endogeneity due to correlation between inputs and unobserved productivity which may impact their conclusions. Taking this issue seriously, Javorcik (2004) and Liu (2008) estimate productivity according to Olley and Pakes (1996) which corrects the endogeneity problem.

Only few studies included FDI spillovers through vertical relationships which occur to local supplier and buyer firms. Javorcik (2004) with Lithuania data, Blalock and Gertler (2008) with Indonesian data, and Liu (2008) with Chinese data examine FDI spillover via backward and forward linkages. They find positive FDI spillover through backward linkages and insignificant forward linkages. However, they do not account for the potential impact of agglomeration and geography on linkages.

All the above studies do not observe sectoral FDI inflows which are important to identify the potential backward and forward linkages. Instead they employ proxy variables. Three popular proxies are output share of foreign firms, employment share of foreign firms and asset share of foreign firms. I do observe FDI inflows at the sector level and the share of foreign ownership at the firm level.

In addition to vertical and horizontal relationships, FDI spillovers also depend partly on geography and agglomeration in sectors. Crozet et al. (2004), Bronzini (2007) and Milner et al. (2006) found evidences of agglomeration and FDI location choices in Italy, France and Thailand, respectively, however, they did not examine FDI spillovers. Aitken and Harrison (1999) is one of the first studies that consider the effects of agglomeration and geography on FDI spillovers. They find that spillovers are insignificant. The more recent empirical studies on FDI spillovers by Halpern and Murakozy (2007) and Jordaan (2011) use data from the manufacturing sector of Hungary and Mexico respectively and find positive horizontal spillovers when controlling for distance and agglomeration. Halpern and Murakozy (2007) use firm-level data and introduce weighted distance into the spillover variables but do not account for agglomeration. Jordaan (2011) accounts for agglomeration by applying Gini coefficient of sectoral employment distribution across states, but uses sectoral data and considers only horizontal relationships.[36]

I improve upon this literature along several dimensions. First, I employ two types of productivity estimates; one based on value added and one based on quantity productivity. These productivity estimates are corrected for endogeneity and allow for monopolistic competition. Second, I intro-

[36]The data employed in Jordaan (2011) is aggregated to industry level at the six-digit Mexican census classification.

duce agglomeration-spatial weights to the spillover variables. These agglomeration-spatial weights are computed at the district level and province level. Finally, I observe FDI inflows at the sectoral level and do not need any proxy variables.

5.3 Empirical Specifications

The objective of this chapter is to examine how FDI inflows affect productivity of other firms through horizontal and vertical relationships. The main focus is on horizontal, forward and backward linkages which determine the spillover of productivity through market competition and intermediate input transactions. The patterns of intermediate input transactions across production sectors are obtained from Input-Output Tables. I introduce agglomeration-spatial weights at province and district levels into the spillover tests because the proximity to clusters of supplier and buyer sectors and their competitors may determine the spillover of productivity.

Similar as in Javorcik (2004) I start with the specification

$$\Delta tfp_{ijt} = \beta_1 \Delta Fsh_{ijt} + \beta_2 \Delta Backward_{jt} + \beta_3 \Delta Forward_{jt} + \beta_4 \Delta HFDI_{jt} + \tag{5.1}$$

$$\beta_5 \Delta HI_{jt} + \beta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_t + \varepsilon_{ijt}$$

where tfp_{ijt} denotes productivity of firm i in sector j at time t, Fsh_{ijt} is percentage of foreign share in total equity of firm j, $Backward_{jt}$, $Forward_{jt}$, and $HFDI_{jt}$ are backward, forward and horizontal variables of sector j respectively. The backward variable represents how FDI in buyer sectors affects firms in sector j, and the forward variable captures the effect of FDI in supplier sectors on firms in sector j. Similarly, the horizontal variable represents the contributions of FDI in the same sector j. The residual ε_{ijt} follows the usual assumptions but we cluster standard errors by industry and year.

Two additional variables that determine firm productivity are the Herfindahl index and the demand for output of sector j as intermediate inputs. HI_{jt}, denotes Herfindahl index of sector j at time t and $IntDem_{jt}$ is demand for output of sector j as intermediate inputs of other sectors. The Herfindahl index captures the impact of market concentration on firm productivity and intermediate demand accounts for scale economies due to increase in production of FDI firms. The remaining three variables are region, year and industry fixed effects.

Since the transmission process may take a long time, I follow Keller and Yeaple (2009) by adding lagged terms of spillover variables into equation (5.1) to obtain

$$\Delta tfp_{ijt} = \beta_1 \Delta Fsh_{ijt} + \sum_{l=0}^{1} \beta_{2l} \Delta Backward_{j,t-l} + \sum_{l=0}^{1} \beta_{3l} \Delta Forward_{j,t-l} + \sum_{l=0}^{1} \beta_{4l} \Delta HFDI_{j,t-l} \quad (5.2)$$

$$+\beta_5 \Delta HI_{jt} + \beta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_I + \varepsilon_{ijt}.$$

Next, I compute spillover variables by multiplying agglomeration-spatial weights with FDI inflows of each sector for horizontal spillover, multiplying agglomeration-spatial weights with input/output shares and FDI inflows to supplier/buyer sectors for forward and backward spillovers respectively. Then equation (5.1) is

$$\Delta tfp_{ijat} = \delta_1 \Delta Fsh_{ijat} + \delta_2 \Delta Backward_{ja,t} + \delta_3 \Delta Forward_{ja,t} + \delta_4 \Delta HFDI_{ja,t} + \quad (5.3)$$

$$\delta_5 \Delta HI_{jt} + \delta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_I + \varepsilon_{ijat}$$

where a denotes the province where firm i resides. Equation (5.2) becomes

$$\Delta tfp_{ijat} = \delta_1 \Delta Fsh_{ijat} + \sum_{l=0}^{1} \delta_{2l} \Delta Backward_{ja,t-l} + \sum_{l=0}^{1} \delta_{3l} \Delta Forward_{ja,t-l} + \sum_{l=0}^{1} \delta_{4l} \Delta HFDI_{ja,t-l} \quad (5.4)$$

$$+\delta_5 \Delta HI_{jt} + \delta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_I + \varepsilon_{ijat}$$

where $Backward_{ja,t-l}$ is the backward variable for firms in sector j which locate in province a

at time $t-l$, and $l=0,1$. This backward variable captures the contribution of proximity from province a to clusters of buyer sectors in all provinces. The idea is that firm i located in province a experiences a greater backward linkage then firm i' located in a' if firm i is located closer to the cluster of buyer sectors compared to firm i'. $Forward_{ja,t-l}$ denotes a forward linkage for firms in sector j which locate in province a at time $t-l$. Similar to the backward linkage, this forward variable captures the contribution of proximity from province a to clusters of seller sectors in all provinces. $HFDI_{ja,t-l}$ represents horizontal variable for firms in sector j which locate in province a at time $t-l$. Analogous to the vertical spillover variables, this horizontal variable controls for the contribution of proximity from province a to clusters of firms in the same sector that locate in all provinces.

I extend the models by adding a exporter indicator and R&D expenditure because exporter firms and firms who invest in R&D may be more productive than non exporters and firms who do not invest in R&D. The augmented specifications are

$$\Delta tfp_{ijat} = \delta_1 \Delta Fsh_{ijat} + \delta_2 \Delta Backward_{ja,t} + \delta_3 \Delta Forward_{ja,t} + \delta_4 \Delta HFDI_{ja,t} + \tag{5.5}$$

$$\delta_5 \Delta HI_{jt} + \delta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_I + \upsilon_{ex} + \upsilon_{R\&D} + \varepsilon_{ijat}$$

and

$$\Delta tfp_{ijat} = \delta_1 \Delta Fsh_{ijat} + \sum_{l=0}^{1} \delta_{2l} \Delta Backward_{ja,t-l} + \sum_{l=0}^{1} \delta_{3l} \Delta Forward_{ja,t-l} + \sum_{l=0}^{1} \delta_{4l} \Delta HFDI_{ja,t-l} \tag{5.6}$$

$$\delta_5 \Delta HI_{jt} + \delta_6 \Delta IntDem_{jt} + \gamma_r + \gamma_y + \gamma_I + \upsilon_{ex} + \upsilon_{R\&D} + \varepsilon_{ijat}$$

where υ_{ex} and $\upsilon_{R\&D}$ are indicator variables for export and R&D investment.

5.4 Data

The data used in this chapter consists of three pieces: the comprehensive data that combines the firm-level data from Thai manufacturing sector and FDI data from ASEAN FDI database, the Input-Output matrix from the Office of National Economic and Social Development Board, and the distance across provinces in Thailand from the Department of Highways, Ministry of Transport.

Similar to the previous chapters, the main dataset employed here is the confidential firm-level data from the manufacturing sector in Thailand from 2001-2006. This dataset is an unbalanced sample from the annual survey on Thailand's industries arranged by the Office of Industrial Economics. The characteristic variables are from the main dataset and the registration database from the Department of Industry Work, Ministry of Industry, Thailand.

There are three sectors that did not attract FDI during the sample period: recycling and manufacturing of office, accounting and computing machine. Owing to investment restrictions in Thailand, tobacco and cigarette sector is reserved for Thai entrepreneurs and there are special regulations that protect this industry from foreign firm competition. Without any specific investment restriction, there are two sectors that did not receive FDI inflows in the sample period: recycling and manufacturing of office, accounting and computing machine. Data from ASEAN FDI database showed that there were FDI inflows to Thai recycling industry only in 2002 and 2003, and there was no FDI inflows to manufacturing of office, accounting and computing machine. Consequently, I have to drop these three sectors from the analysis. In addition I employ two types of productivity estimates from Chapter 3 as outcomes of the firms.

5.5 Variables

5.5.1 Agglomeration-Spatial Weight Variables

I introduce agglomeration-spatial weight variables to control for proximity of the firms to clusters of their competitors, suppliers, and buyers. The spatial weights will capture the impacts of geographical proximity on firm performance while agglomeration indicators will capture the impacts of clusters on firm performance. In this chapter, two levels of agglomeration are introduced: province and district levels. They will be multiplied with spillover variables which will generate spillover variables that capture the effects of agglomeration and geographical space on FDI spillovers.

To compute agglomeration-spatial weight variables, I construct the spatial weight variables

$$w_{ab} = 1 - \frac{d_{ab}}{Band},$$

where w_{ab} is the spatial weight of province a to province b, d_{ab} is the distance in kilometers between city halls of province a and province b, and $Band$ is the bandwidth which is the maximum of d_{ab}. This spatial weight variable will be small if province a is far from province b and will be large if both provinces are nearby. The spatial weight will be equal to one if a and b are the same province.

As the sizes of firm clusters in each sector differs across provinces/districts, I compute firm clusters by province and district.[37]

I define a cluster indicator of sector j at the province level as

$$fdenp_{sb} = \frac{f_{sb}}{F_s},$$

where $fdenp_{sb}$ is the density of firms in sector s in province b, f_{sb} is the number of firms located in province b. F_s is the number of firms in sector s in Thailand. This firm density weight will capture agglomeration effects on spillover at the province level.

[37] I cannot observe locations of all operating firms in Thailand. Therefore the firm density variables are computed from the firms in the survey.

At the district level, I compute firm density variables analogous to those at the province level

$$fdenz_{sbz} = \frac{f_{sbz}}{F_{sb}},$$

where $fdenz_{sbz}$ indicates the firm density of sector s in province b, f_{sbz} is the number of firms in sector s located in zip code area z of province b. F_{sb} denotes the number of firms in sector s located in province b.

I compute a agglomeration-spatial weight variable at the district level by multiplying $fdenz_{sbz}$ with $fdenp_{sb}$ and w_{ab}. Therefore the agglomeration-spatial-weight variables are

$$asw_{sabz} = w_{sb} \times fdenp_{sb} \times fdenz_{sbz}$$

I multiply w_{ab} with firm density of sector s in district z of province b and firm density of sector s in province b to generate agglomeration-spatial weight that capture relationship between firms in sector s locating in district z of province b and firms in province a. If a and b are the same province, the weight is equal to the firm density of sector s in province a because w_{aa} equals 1, which will capture proximity to firms in the same district in the same province.

For horizontal spillover, I use the firm density of competitors in district z of province b, and firm density of competitors in province b. Similarly, for vertical spillover I use the firm density of supplier sectors at the district and province levels for forward linkages. I use the firm density of the buyer sectors at the district and province levels for the backward linkage.

5.5.2 Input and Output Proportion Variables

The Input-Output matrix employed here expresses the production pattern of Thailand in 2005. From the Input-Output matrix, I compute input shares and output shares of each sector. The input and output shares reflect the relationships across production sectors through intermediate input transactions.

When considering sector j as a purchaser sector, the relationships between sector j and other sectors are reflected through input shares. The input share σ_{jm} is the proportion of input value that sector j purchased from sector m to total input values of sector j.

$$\sigma_{jm} = \frac{intinp_{jm}}{totalinp_j}$$

where $intinp_{jm}$ denotes input value that sector j purchased from sector m, and $totalinp_j$ is total input value purchased by sector j.

When considering sector j as a seller sector, the relationships between sector j and other sectors are reflected through output shares. The output share α_{jk} is the proportion of output value that sector j sold to sector k to total output values of sector j.

$$\alpha_{jk} = \frac{intout_{jk}}{totalout_j}$$

where $intout_{jk}$ equals output value that sector j sold to sector k, $totalout_j$ denotes total output value sold by sector j, and I use σ_{jm} and α_{jk} to compute forward and backward variables respectively.

5.5.3 FDI Spillover Variables

Spillover can be transmitted through horizontal and vertical relationships. The spillover through horizontal relationships is the effect from FDI firms on other firms in the same sector, and the spillover through vertical relationships is the effect from FDI firms on firms in other sectors that are within the same supply chain.

The horizontal spillover reflects how firms are influenced by their foreign competitors. Therefore the horizontal variable for the baseline is simply the FDI inflows to the sectors in focus.

$$HFDI_{jt} = FDI_{jt}$$

where $HFDI_{jt}$ denotes horizontal variable of sector j at time t, FDI_{jt} is log of FDI inflows to sector j at time t. Then I introduce the agglomeration-spatial weights at province level to horizontal variable.

$$HFDI_{jat} = FDI_{jt} \times \frac{\sum_{b=1}^{maxp_j} (\sum_{z=1}^{maxz_{jp}} asw_{jabz})/maxz_{jp}}{maxp_j}$$

where $HFDI_{jat}$ is horizontal variable of sector j in province a at time t, FDI_{jt} indicates log of FDI inflows to sector j at time t, asw_{jabz} denotes agglomeration-spatial weight of clusters of sector j in district z of province b for firms in province a.

To obtain the average agglomeration spatial weights, first, I add up asw_{jabz} of districts in province b and divide by $maxz_{jp}$ which is number of districts that host clusters j in province b. Then I add up the averages of agglomeration-spatial weights of all provinces for sector j in province a and divide by $maxp_j$, which is the number of provinces that host clusters of sector j .

The horizontal variable of sector j reflects how performance of firms in sector j , which locate in province a, changes responding to FDI inflows to sector j when accounting for proximity to clusters of sector j in all provinces.

Unlike horizontal relationship, FDI spillover through vertical relationship occurs to firms in other sectors. The FDI spillover can be transferred through intermediate input transactions across sectors. I Javorcik (2004) by introducing province and district level agglomeration-spatial weight of supplier and buyer sectors to input and output shares, then multiplying with FDI inflows to supplier and buyer sectors.

The backward variables reflect how FDI inflows to buyer sectors affect performance of firms in sector j. A backward variable for the baseline is computed as

$$Backward_{jt} = \sum_{k \neq j} \alpha_{jk} \times FDI_{kt}$$

where $Backward_{jt}$ represents backward variable of sector j at time t, α_{jk} denotes output share of sector j sold to sector k at time t. Then I introduce agglomeration-spatial weights at province and district level to the backward variable,

$$Backward_{jat} = \sum_{k \neq j} back_{jak} \times FDI_{kt}$$

where

$$back_{jak} = \alpha_{jk} \times \frac{\sum_{b=1}^{maxp_k} (\sum_{z=1}^{maxz_{kb}} asw_{kabz})/maxz_{kb}}{maxp_k}.$$

$maxz_{kb}$ denotes number of districts in province b that host clusters of sector k. Similarly, $maxp_k$ represents number of provinces that host clusters of sector k. Therefore $Backward_{jat}$ indicates how much FDI inflows to downstream sectors influence firms in a given sector j, which locate in province a, when controlling for proximity to clusters of downstream sectors in all provinces.[38] The agglomeration for backward linkages is the agglomeration of clusters of buyer sectors, which is indexed by k, in all provinces.

Analogously, the forward variables reflect how FDI inflows to supplier sectors impact performance of firms in a given sector j, which locate in province a, when controlling for proximity to clusters of supplier sectors in all provinces. A forward variable for the baseline is computed by

$$Forward_{it} = \sum_{m \neq j} \sigma_{jm} \times FDI_{mt}$$

[38] The index k represents downstream sectors.

Then introduce the agglomeration-spatial weights are province and district level.

$$Forward_{jat} = \sum_{m \neq j} forw_{jam} \times FDI_{mt}$$

where

$$forw_{jam} = \sigma_{jm} \times \frac{\sum_{b=1}^{maxp_m} (\sum_{z=1}^{maxz_{mp}} asw_{mabz})/maxz_{mp}}{maxp_m}$$

$maxz_{mb}$ denotes number of districts in province b that host clusters of sector m. Similarly, $maxp_m$ represents number of provinces that host clusters of sector m. Therefore $Forward_{jat}$ expresses how FDI inflows in upstream sectors influence firms in sector j that locate in province a when controlling for proximity to clusters of upstream sectors in all provinces.[39] The agglomeration for forward linkages is the agglomeration of clusters of supplier sectors, which is indexed by m, in all provinces.

5.5.4 Other Variables

As FDI inflows may decrease concentration of producers and thus intensify market competition, a Herfindahl index will capture the impact of market competition on firm performance. Furthermore, FDI inflows may increase demand for intermediate inputs which will benefit local suppliers in terms of production scale, but not technology or knowledge transfers.

The Herfindahl index is computed by

$$HI_{jt} = \sum_{i=1}^{4} (marketshare_{ijt})^2$$

where HI_{jt} denotes Herfindahl index of sector j at time t, and $marketshare_{ijt}$ is the market share of firm i. HI_{jt} is the sum of the squared market shares of the four largest firms.[40]

[39] The index m represents upstream sectors.

[40] Since I cannot observe the information of all active firms, I compute lHI_{jt} with the information in the dataset at hand which may not precisely capture the actual market concentration. However, the majority of the responding firms

The intermediate input demand is computed in terms of both revenue and physical outputs.

$$intdv_{jt} = \sum_{k \neq j} o_{jk} \times sectorsale_{kt}$$

where $intdv_{jt}$ is intermediate input demand of sector j in terms of revenue, $sectorsales_{kt}$ equals the log of sales of sector k, and o_{jt} represents the share of output that sector j sold to sector k to produce one unit of sector k outputs

$$o_{jk} = \frac{intout_{jk}}{totalout_k},$$

where $intout_{jk}$ equals output of sector j sold to sector k, and $totalout_k$ equals total output value of sector k.

Note that o_{jk} is not equal to α_{jk} and total output of sector k is total output values from Input-Output table, while total sales of a sector is computed from the information in the dataset. To compute intermediate input demand in terms of quantity ($intdq_{jt}$), I replace $sectorsales_{kt}$ with $sectorq_{kt}$ which is the total sold quantity of sector k in time t.[41]

5.6 Results

Table 5.1 shows the baseline estimation results. The table consists of two main panels. The left panel illustrates the results for value added productivity and the right panel shows the results for quantity productivity. The first column of each panel shows the result from equation (5.1) when including all firms. The second column of each panel illustrates the result of equation (5.2) when including all firms. The third column of each panel shows the result from equation (5.1) when including only Thai firms, and the fourth column is the result from equation (5.4) when including

are the medium and large firms as elaborated in Chapter 2.

[41] I subtract each firm's produced quantity with its change in quantity inventory, then sum up the quantity sold of all firms in each sector in each year.

only Thai firms. All tables in this section will follow this format.

The results in Table 5.1 indicate that the FDI spillover through the backward linkages negatively impacts both value added and quantity productivity. The effects on value added productivity are smaller than the effects on quantity productivity. In addition, the spillover on quantity productivity through horizontal spillover is positive when including all firms without adding lagged terms of spillover variables. However, when we include the lags into the specification, the lagged horizontal linkage has a negative significant impact on physical productivity. These results suggest that FDI in buyer firms decrease market values and efficiency of the local firms, and FDI inflows to the sectors immediately improve firm efficiency but decrease firm efficiency in the future.

The results from the baseline contradict the finding for developing countries in previous literature such as Javorcik (2004), Blalock and Gertler (2008), and Liu (2008) who found positive spillover through backward linkages in developing countries. The key differences between the specifications in the first panel of Table 5.1 and those three previous studies on FDI spillover on productivity are the productivity estimates, which are estimated under multiple-product firm setting, and sectoral FDI inflows, which they did not observed but proxied with aggregation of foreign share at the firm level.

Table 5.2 shows the estimation results of equations (5.3) and (5.4) when accounting for agglomeration and geography. The results exhibit positive FDI spillovers on value added productivity of Thai firms through backward linkages in the first lagged term and negative spillovers through forward linkages in the first lagged term. This demonstrates FDI inflows to buyer sectors increase firms' productivity but FDI inflows to supplier sectors worsen firms' productivities.

In contrast, FDI spillovers are more apparent for quantity productivity. The results show that the contemporaneous terms of backward and forward are significant for quantity productivity when including all firms in the tests, and the horizontal spillover exists when considering only Thai firms. It can be interpreted that FDI inflows to the buyers who locates nearby improve production efficiency of all firms, but the FDI inflows to the suppliers nearby decrease production efficiency of all firms. In addition, the FDI inflows to the competitors worsen Thai firms' production efficiency. The evidence reflect that the FDI spillovers has immediate impacts on all local firms' efficiency, however, the effects on market values of all local firms are slowly absorbed. In addition, FDI spillovers do not significantly improve the production efficiency of Thai firms.

When controlling for agglomeration and geography, the results are consistent with the findings in previous literature that positive FDI spillovers occurred through backward linkages. The differences between results in Table 5.1 and 5.2 reflect the importance of agglomeration and geography on FDI spillovers. Apparently, agglomeration and geography substantially determine the occurrence of spillovers in Thailand.

As the FDI inflows to high-technology sectors were much larger than other sectors, it is expected that, if FDI spillover exists, firms in these sectors should benefit from FDI more than firms in other sectors. Therefore I split the data into two subgroups: high-FDI sectors and low-FDI sectors, and estimate equation (5.3) and (5.4) for each subgroup.[42]The results for high-FDI sectors illustrated in Table 5.3 exhibit the significant FDI spillover on value added productivity through horizontal relationship when including all firms in the estimation. Moreover, the results for quantity productivity are all insignificant which indicates that FDI spillovers do not impact production efficiency of firms in these sectors.

In contrast, when considering subgroup in low-FDI sectors the FDI spillovers are more pronounced. Table 5.4 illustrates the results for low-FDI subgroup. The results show that FDI spillovers have impacts on both value added and quantity productivity these sectors. The FDI spillovers through backward linkages have positive impacts on value added productivity, however, only lagged terms are significant. In addition, the FDI spillover through forward linkages has negative impact on value added productivity of Thai firms. The results indicate positive spillovers on quantity productivity through backward linkages, but negative spillovers on quantity productivity

[42]I also estimated 5.1 for both subgroups, however, the results exhibit no FDI spillover for firms in high-FDI sectors and strong negative spillovers through backward linkages for firms in low-FDI sectors, which is similar to the baseline results.

through forward linkages. These effects are larger when adding lagged terms of spillover variables. Moreover, there are evidences of significant negative horizontal spillovers on quantity productivity in low-FDI sectors. The more apparent FDI spillovers in low-FDI sectors reflect that local supplier firms benefit from FDI more than local competitors, while local buyer firms experience losses, which implies the role of vertical linkages on FDI spillovers. In addition, Thai firms in low-FDI sectors benefit from FDI only through backward linkages.

Table 5.5 shows the extension including an exporter and R&D indicator variable. The impact of linkages on productivity is largely consistent to the estimates without these variables presented in Table 5.2.

Overall, the results exhibit positive FDI spillovers through backward linkages and negative FDI spillovers through forward linkages. The significant FDI spillovers through horizontal relationships are positive in high-FDI sectors when including all firms, and negative in low-FDI sectors. There are several important take away. First, spillover effects do exist in Thailand. However, whether they are positive or negative varies across the specifications, the sample, the definition of the linkage and the timing.

5.7 Conclusion

The enormous costs incurred from investment policies and privileges to attract FDI inflows raise questions for governments of the host countries if all the attempts are worthwhile. Thailand is one of the developing countries that have received substantial FDI inflows since the Asian financial crisis in 1997 and has invested in infrastructures as well as offered privileges to foreign firms.

In the past Thailand focused on attracting FDI in the motor vehicle and communication equipment industries. My results highlight the complexity in evaluating the impact of FDI on productivity. Who benefits and who loses from FDI is not a clear cut answer but depends on several characteristics.

The results show that FDI spillovers exist through both vertical and horizontal relationships. The positive FDI spillovers occur through backward linkages while the negative spillovers occur through forward linkages and horizontal relationships. Moreover, when splitting data into high and low FDI sectors, the results demonstrate that the FDI spillovers do not exist in high-FDI sectors, but they appear significant in low-FDI sectors. This implies that FDI inflows benefits Thai supplier firms but not buyer and competitor firms. Furthermore, the existence and direction of the spillover effects depends on the definition of the linkage.

To inform policy of the potential benefits of FDI requires that future research identifies the characteristics that impact the benefits from FDI. This study has focused on advancing productivity estimates the definition of the linkages. I expect that future research will make advances along these and several other margins.

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Table 5.1: Base Case

Variables	First Difference Value Added Productivity				First Difference Quantity Productivity			
	All Firms		Thai Firms		All Firms		Thai Firms	
	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags
ΔForeign Share	0.000819	0.000766			0.00156	0.00162		
	(0.000642)	(0.000643)			(0.00142)	(0.00142)		
ΔBackward	-0.0974**	-0.0926*	-0.147***	-0.145***	-0.312**	-0.316**	-0.261**	-0.247**
	(0.0470)	(0.0486)	(0.0519)	(0.0525)	(0.132)	(0.129)	(0.116)	(0.117)
ΔForward	-0.00605	0.00736	-0.00494	-0.00576	0.0122	-0.0590	-0.0622	-0.0777
	(0.0175)	(0.0277)	(0.0208)	(0.0287)	(0.0520)	(0.0792)	(0.0572)	(0.0771)
ΔHorizontal	0.00868	0.0141	0.00604	0.0157	0.0289*	0.00713	0.0139	-0.0191
	(0.00773)	(0.0105)	(0.00804)	(0.0106)	(0.0154)	(0.0248)	(0.0174)	(0.0282)
ΔFirst Lagged		0.0256		0.0274		0.0474		0.0370
Backward		(0.0349)		(0.0385)		(0.0718)		(0.0662)
ΔFirst Lagged		0.0211		-0.000538		-0.128		-0.0402
Forward		(0.0338)		(0.0348)		(0.122)		(0.0866)
ΔFirst Lagged		0.00753		0.0133		-0.0280		-0.0450*
Horizontal		(0.00883)		(0.00930)		(0.0246)		(0.0273)
ΔHerfindahl	5.12e-06	9.38e-06	-6.68e-05*	-6.75e-05*	-3.18e-05***	-3.31e-05***	-2.37e-05***	-2.08e-05**
Index in Value	(3.96e-05)	(4.07e-05)	(3.90e-05)	(3.95e-05)	(9.64e-06)	(1.12e-05)	(9.02e-06)	(9.65e-06)
ΔIntermediate	3.59e-06	4.29e-06	3.08e-06	3.65e-06	4.52e-07	-1.26e-06	-4.37e-06	-4.57e-06
Demand in Value	(3.36e-06)	(3.46e-06)	(3.40e-06)	(3.46e-06)	(9.99e-06)	(1.01e-05)	(9.32e-06)	(9.47e-06)
Observations	4,644	4,585	3,531	3,480	4,543	4,491	3,449	3,402
R-squared	0.026	0.026	0.037	0.038	0.022	0.023	0.036	0.037

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 5.2: Introduce Spatial Weights at Province and District Level

Variables	First Difference Value Added Productivity				First Difference Quantity Productivity			
	All Firms		Thai Firms		All Firms		Thai Firms	
	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags
ΔForeign Share	0.000738	0.000665			0.00135	0.00128		
	(0.000665)	(0.000666)			(0.00150)	(0.00151)		
ΔBackward	0.000393	0.000559	3.97e-05	0.000151	0.00123*	0.00153*	0.000746	0.000871
	(0.000374)	(0.000360)	(0.000399)	(0.000367)	(0.000715)	(0.000778)	(0.000854)	(0.000884)
ΔForward	-0.000224	-0.000294	0.000203	0.000205	-0.00199**	-0.00214**	-0.00125	-0.000833
	(0.000388)	(0.000396)	(0.000433)	(0.000432)	(0.000875)	(0.000993)	(0.00104)	(0.00110)
ΔHorizontal	0.00905	0.0122	0.00443	0.0144	0.0191	-0.00367	0.0116	-0.0155
	(0.00818)	(0.0113)	(0.00837)	(0.0119)	(0.0172)	(0.0248)	(0.0187)	(0.0274)
ΔFirst Lagged		0.000555*		0.000731**		0.000340		0.000255
Backward		(0.000315)		(0.000337)		(0.000681)		(0.000795)
ΔFirst Lagged		-0.000381		-0.000509*		-0.000286		-0.000546
Forward		(0.000254)		(0.000278)		(0.000554)		(0.000659)
ΔFirst Lagged		0.00511		0.0133		-0.0382		-0.0567**
Horizontal		(0.00938)		(0.00921)		(0.0238)		(0.0275)
ΔHerfindahl	1.60e-05	1.34e-05	-5.48e-05	-6.08e-05	-3.12e-05***	-2.73e-05**	-2.11e-05**	-1.45e-05
Index in Value	(4.52e-05)	(4.61e-05)	(4.51e-05)	(4.60e-05)	(1.02e-05)	(1.08e-05)	(9.98e-06)	(1.07e-05)
ΔIntermediate	4.16e-06	4.27e-06	2.76e-06	2.97e-06	-2.78e-07	-2.96e-07	-1.19e-05	-1.19e-05
Demand in Value	(3.32e-06)	(3.33e-06)	(3.33e-06)	(3.32e-06)	(1.09e-05)	(1.07e-05)	(1.14e-05)	(1.14e-05)
Observations	4,039	3,980	3,050	2,999	3,947	3,895	2,978	2,931
R-squared	0.027	0.028	0.037	0.040	0.014	0.015	0.009	0.011

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 5.3: Introduce Spatial Weights at Province and District Zip code Level Considering High-FDI Sectors

Variables	First Difference Value Added Productivity				First Difference Quantity Productivity			
	All Firms		Thai Firms		All Firms		Thai Firms	
	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags
ΔForeign Share	0.00201	0.00211			0.000404	0.000131		
	(0.00128)	(0.00129)			(0.00241)	(0.00251)		
ΔBackward	0.00190	0.00240	0.00109	0.00155	-0.00324	-0.00146	-0.00640	-0.00560
	(0.00264)	(0.00252)	(0.00257)	(0.00267)	(0.00503)	(0.00577)	(0.00593)	(0.00674)
ΔForward	-0.00187	-0.00243	-0.000867	-0.00126	0.00313	0.00257	0.00609	0.00685
	(0.00282)	(0.00262)	(0.00278)	(0.00290)	(0.00535)	(0.00608)	(0.00625)	(0.00732)
ΔHorizontal	0.0290*	0.0357**	0.0139	0.0272	0.0105	0.00948	0.0169	0.00804
	(0.0153)	(0.0166)	(0.0135)	(0.0197)	(0.0350)	(0.0395)	(0.0474)	(0.0547)
ΔFirst Lagged		-0.000725		-0.000107		0.00211		0.00283
Backward		(0.00124)		(0.00114)		(0.00218)		(0.00280)
ΔFirst Lagged		0.000340		-0.000153		-0.00215		-0.00251
Forward		(0.000928)		(0.000908)		(0.00158)		(0.00197)
ΔFirst Lagged		0.0142		0.0187		-0.0645		-0.0945
Horizontal		(0.0221)		(0.0241)		(0.0436)		(0.0604)
ΔHerfindahl	3.32e-05	8.64e-05	-5.46e-05	-6.19e-05	-5.63e-05*	-5.51e-05*	-3.30e-05	-3.17e-05
Index in Value	(7.23e-05)	(7.37e-05)	(7.14e-05)	(7.37e-05)	(2.89e-05)	(2.93e-05)	(2.72e-05)	(2.81e-05)
ΔIntermediate	-9.48e-07	-4.02e-06	5.69e-07	2.00e-06	2.19e-06	2.42e-06	-2.59e-05	-2.82e-05
Demand in Value	(7.84e-06)	(7.74e-06)	(8.61e-06)	(9.05e-06)	(1.28e-05)	(1.29e-05)	(1.82e-05)	(1.85e-05)
Observations	1,433	1,365	901	901	1,338	1,338	879	879
R-squared	0.036	0.045	0.057	0.058	0.023	0.026	0.008	0.012

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 5.4: Introduce Spatial Weights at Province and District Level Considering Low-FDI Sectors

Variables	First Difference Value Added Productivity				First Difference Quantity Productivity			
	All Firms		Thai Firms		All Firms		Thai Firms	
	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags
ΔForeign Share	-0.000138	-0.000250			0.00160	0.00159		
	(0.000510)	(0.000506)			(0.00189)	(0.00193)		
ΔBackward	0.000227	0.000541	-6.67e-05	0.000161	0.00129*	0.00188**	0.00114	0.00149*
	(0.000401)	(0.000386)	(0.000413)	(0.000383)	(0.000711)	(0.000769)	(0.000850)	(0.000835)
ΔForward	-0.000159	-0.000407	0.000223	5.96e-05	-0.00227**	-0.00293***	-0.00163	-0.00164
	(0.000411)	(0.000428)	(0.000444)	(0.000449)	(0.000898)	(0.00104)	(0.00107)	(0.00112)
ΔHorizontal	-0.00871	-0.0109	-0.00736	-0.00137	0.00418	-0.0293	0.00721	-0.0289
	(0.00750)	(0.00987)	(0.00913)	(0.0121)	(0.0210)	(0.0276)	(0.0211)	(0.0261)
ΔFirst Lagged		0.000676**		0.000787**		-5.51e-05		-0.000275
Backward		(0.000302)		(0.000339)		(0.000715)		(0.000875)
ΔFirst Lagged		-0.000409		-0.000484*		0.000235		8.72e-05
Forward		(0.000253)		(0.000282)		(0.000597)		(0.000722)
ΔFirst Lagged		0.000408		0.0106		-0.0418*		-0.0555*
Horizontal		(0.00886)		(0.00957)		(0.0247)		(0.0284)
ΔHerfindahl	-4.36e-05	-4.80e-05	-6.56e-05	-7.85e-05	-2.40e-05**	-1.87e-05	-1.44e-05	-6.19e-06
Index in Value	(6.10e-05)	(6.37e-05)	(6.69e-05)	(6.91e-05)	(1.14e-05)	(1.20e-05)	(1.03e-05)	(1.03e-05)
ΔIntermediate	-8.91e-07	-8.23e-07	-1.10e-06	-8.75e-07	-1.41e-05	-1.31e-05	-1.25e-05	-1.12e-05
Demand in Value	(4.19e-06)	(4.15e-06)	(4.73e-06)	(4.59e-06)	(1.62e-05)	(1.62e-05)	(1.53e-05)	(1.55e-05)
Observations	2,674	2,615	2,149	2,098	2,609	2,557	2,099	2,052
R-squared	0.026	0.028	0.034	0.037	0.015	0.016	0.015	0.017

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Table 5.5: Introduce Spatial Weights at Province and District Level with Export, R&D

Variables	First Difference Value Added Productivity				First Difference Quantity Productivity			
	All Firms		Thai Firms		All Firms		Thai Firms	
	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags	No Lags	With Lags
ΔForeign Share	0.000749	0.000675			0.00139	0.00137		
	(0.000671)	(0.000671)			(0.00151)	(0.00153)		
ΔBackward	0.000387	0.000547	3.03e-05	0.000138	0.00120*	0.00142*	0.000736	0.000775
	(0.000374)	(0.000362)	(0.000404)	(0.000371)	(0.000722)	(0.000780)	(0.000859)	(0.000895)
ΔForward	-0.000217	-0.000270	0.000215	0.000242	-0.00198**	-0.00204**	-0.00120	-0.000772
	(0.000388)	(0.000396)	(0.000436)	(0.000433)	(0.000886)	(0.000985)	(0.00104)	(0.00110)
ΔHorizontal	0.00895	0.0121	0.00394	0.0142	0.0178	-0.00962	0.0114	-0.0243
	(0.00817)	(0.0113)	(0.00841)	(0.0121)	(0.0183)	(0.0279)	(0.0204)	(0.0313)
ΔFirst Lagged		0.000560*		0.000768**		0.000301		0.000250
Backward		(0.000316)		(0.000339)		(0.000721)		(0.000856)
ΔFirst Lagged		-0.000395		-0.000549**		-0.000350		-0.000646
Forward		(0.000253)		(0.000277)		(0.000568)		(0.000684)
ΔFirst Lagged		0.00495		0.0133		-0.0437*		-0.0639**
Horizontal		(0.00945)		(0.00940)		(0.0264)		(0.0302)
ΔHerfindahl	1.62e-05	1.36e-05	-5.54e-05	-6.14e-05	-3.15e-05***	-2.75e-05**	-2.12e-05**	-1.52e-05
Index in Value	(4.49e-05)	(4.58e-05)	(4.47e-05)	(4.57e-05)	(1.00e-05)	(1.07e-05)	(9.60e-06)	(1.06e-05)
ΔIntermediate	4.12e-06	4.21e-06	2.62e-06	2.79e-06	-4.62e-07	-7.04e-07	-1.23e-05	-1.26e-05
Demand in Value	(3.33e-06)	(3.34e-06)	(3.31e-06)	(3.30e-06)	(1.08e-05)	(1.07e-05)	(1.14e-05)	(1.14e-05)
Export Dummy	0.0193	0.0200	0.0363*	0.0382*	0.0534	0.0496	0.0767*	0.0711
	(0.0160)	(0.0162)	(0.0194)	(0.0196)	(0.0410)	(0.0411)	(0.0463)	(0.0470)
R&D Dummy	-0.0126	-0.0112	-0.0170	-0.0134	-0.0375	-0.0637	-0.0284	-0.0807
	(0.0264)	(0.0268)	(0.0281)	(0.0288)	(0.0454)	(0.0542)	(0.0474)	(0.0553)
Observations	4,039	3,980	3,050	2,999	3,947	3,895	2,978	2,931
R-squared	0.028	0.029	0.039	0.041	0.015	0.016	0.010	0.012

Standard errors are in parentheses, *** indicates p-value<0.01, ** indicates p-value<0.05, and * indicates p-value<0.1

Vita

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