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Firm's Absorptive capacity: the case of Vietnamese manufacturing firms

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Abstract: Absorptive capacity is an essential factor for the development of any firm. Hence, numerous researchers use it when proposing different approaches and measurements. However, due to the ambiguity of definition of absorptive capacity, some studies focused on the within-firm aspects of absorptive capacity while some looked at the inter-firm aspects. Consequently, there are several proxies for absorptive capacity, which are unlikely to reach an agreement. Therefore, this study aims for the simplified measurement by defining the absorptive capacity of a firm as the gap in persistent efficiency between the firm and the best foreign firm in the same industry. The persistent efficiency of a firm is estimated by using single stage maximum likelihood method. This measurement is applied to the case of Vietnamese manufacturing firms from 2007 to 2015 to estimate the domestic absorptive capacity. The results show that domestic firms in the manufacture of tobacco products sub-sector have the best absorptive capacity and the manufacture of beverages sub-sector have the worst one. Finally, the validity of the proxy is confirmed when the study finds the positive correlation between absorptive capacity and a firm's age, size, technology level and skills of its workers.

Key words: Absorptive capacity, Persistent efficiency, Vietnamese manufacturing firms.

JEL classification: D240

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Introduction

Absorptive capacity is crucial for the development of firms and hence various studies examine the importance and contribution of this factor (Bodman & Le, 2013; Cohen & Levinthal, 1989; Fosfuri & Tribo, 2008; Lane & Lubatkin, 1998; Zahra & George, 2002). The most cited definition of absorptive capacity is the one of Cohen & Levinthal (1989), stating that it is the capability of a firm to recognize, learn and apply new knowledge into the operation and production. Successively, many authors use the definition and attempt to analyze absorptive capacity in their own ways. For example,

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Zahra & George (2002), based on the root definition of Cohen & Levinthal, develop a reconceptualization of absorptive capacity. The authors argue that absorptive capacity can have four interconnected dimensions: acquisition, assimilation, transformation and exploitation. Lane, Koka, & Pathak (2006) meta-analyze the literature on absorptive capacity and suggest a modified definition of absorptive capacity. The authors claim that there should be three stages of utilizing external knowledge: the first one is to identify and understand the new knowledge via empirical studying, the second one is to adapt new knowledge into practice, and the final one is to create new knowledge based on what has been learned (Lane et al., 2006, p. 856). Respectively, there are various proxies for absorptive capacity (such as R&D intensity, R&D expenditures, patents, human capital or technology gap) which are unlikely to reach an agreement.

Therefore, the present study contributes another proxy that can simplify the measurement of absorptive capacity. The absorptive capacity of a firm is considered the capability gap between this firm and the best firm in the same industry. The main interest of the paper is the capability of domestic firms to absorb benefits from foreign firms[3]. Therefore, the gap in capability here is the gap between domestic firms and the best foreign firm in the industry. It can be considered as foreign direct investment (FDI) absorptive capacity. Instead of trying to break down the capability of a firm into various dimensions, the paper simplifies the issue by measuring it as the persistent efficiency of firms. According to Kumbhakar, Lien, & Hardaker (2014), the persistent efficiency and residual efficiency are components of technical efficiency. While the residual efficiency is the short-term effect and may not occur in the following years, the persistent efficiency is the long-term factor and it is unlikely to change unless a big chance in the industry or in the management mechanism happens. Therefore, persistent efficiency could be a good proxy for internal capability, which is firm-specific. Then, the relative gap in persistent efficiency between one firm and the best foreign firm in the same industry is used to proxy for absorptive capacity of the domestic firm.

Note that this method to measure absorptive capacity might be applied to any country and region where foreign firms play an important role in economic development, including Central and East European countries or East Asian countries. If the absorptive capacity of domestic firms is weak, it means the domestic firms are unable to gain much from cooperating with foreign partners. Then the market may be dominated by the foreign firms. In order to check the validity of the proxy, the paper applies to Vietnamese manufacturing firms. Vietnam is an emerging economy where firms are a catalyst for the economic development. The manufacturing sector contributes significantly to the industrial performance. However, there are many obstacles which hamper the development of business section, including poor business environment, not-high technology level or poor managerial skills etc. (Tran, Pham & Vu, 2014). Additionally, the economic development of Vietnam seems to depend on foreign firms and Vietnam lacks big companies that could lead the market. Hence, Vietnam needs improving the capabilities of domestic firms to compete with foreign counterparts. Otherwise it could be stuck in the middle-income trap. Consequently, it is vital to identify the capability of domestic firms as a base for further development progress.

[3] Foreign firms are firms where foreign investors hold more than 50% of the charter capital.

Therefore, the author believes that Vietnam is a good case to apply this measurement for absorptive capacity at firm level.

The paper is organized as follows. The next part generally provides the theoretical background of the study by reviewing the definitions and measurements of absorptive capacity before going to the concept of persistent efficiency. The third part discusses in detail the methodology to measure absorptive capacity and application in the case of Vietnam. It is followed by the findings and conclusion parts.

1. Theoretical background

1.1. Definitions and approaches of absorptive capacity

The term "absorptive capacity" is was first used by Cohen & Levinthal (1989) in the close relationship with R&D activities of firms. However, R&D activity is not the same as absorptive capacity. R&D creates not only innovation but also capability of a firm to "identify, assimilate and exploit knowledge from the environment" (Cohen & Levinthal, 1989, p. 569) and the authors firstly define this capability as a firm's absorptive capacity. Essentially, the absorptive capacity is a prerequisite for firms to generate new knowledge. Then, Cohen & Levinthal (1990) slightly revise the definition of absorptive capacity as "the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends" (Cohen & Levinthal, 1990, p. 1). Absorptive capacity requires the prior related knowledge. It implies that in order to learn new skills, knowledge or technique, the worker (at the individual level) and the firm (at the organizational level) should already have a related background on the skills, knowledge or technique. Certainly, the absorptive capacity of a firm depends on the absorptive capacity of its members. However, it is not a simple summation; it also depends on the internal organization of this firm. At any level, Cohen & Levinthal (1990) underline the importance of prior knowledge. The authors argue that absorptive capacity is cumulative and therefore the "richer" prior related knowledge is, the better is absorptive capacity. Additionally, absorptive capacity can help a firm to predict a new technological trend that could create new business opportunities (Cohen & Levinthal, 1994).

In fact, the definition of absorptive capacity of Cohen & Levinthal is ambiguous. Consequently, there are various studies that have re-defined and developed it. Some of them focus on the within-firm aspect of absorptive capacity. Szulanski (1996) argues that internal knowledge transfer is crucial to create the comparative advantage of firms. Zahra & George (2002), based on Cohen & Levinthal's definition, state that absorptive capacity is a dynamic capability that directly affects the competitiveness of a firm. The authors put forward a new reconceptualization of this term. Then, absorptive capacity of firms is divided into four dimensions that are interdependent on each other. They are acquisition, assimilation, transformation and exploitation. Zahra & George (2002) group acquisition and assimilation into the potential absorptive capacity that relates to the capability of a firm to identify and acquire new knowledge. Nevertheless, the potential absorptive capacity does not ensure that the firm could apply new knowledge in practice. Therefore, it is necessary to have the realized absorptive capacity (which includes transformation and exploitation). The authors state that absorptive capacity depends not only on prior knowledge, but also on knowledge complementarity and knowledge resources diversification. Tu, Vonderembse, Ragu-Nathan, & Sharkey (2006) support the perspective that underlines the importance of internal knowledge development and suggest a broader definition, stating that absorptive capacity should be an organizational mechanism that helps to identify an assimilate both internal and external knowledge and apply it to improve the productivity of a firm. Martinkenaite & Breunig (2015) also examine the importance of the firm-level absorptive capacity and argue that individual and organizational absorptive capacity are different. Then, a firm's absorptive capacity requires the interaction between micro level (individual) and macro level (firm).

From another perspectives, some papers value the importance of inter-firm factors when studying the absorptive capacity of firms. Lane & Lubatkin (1998) pay attention to the relative absorptive capacity, claiming that a firm has the same starting point to learn new knowledge as long as this firm can choose the appropriate partners. Lane & Lubatkin (1998) shift the analysis to external learning of firms. More specifically, the "student" firm can learn more effectively from the "teacher" firm if they share some common characteristics and the student firm somehow has a sound background about new knowledge offered by the teacher firm. This argument to some extent coincides with the idea of Dyer & Singh (1998). Dyer & Singh (1998) state that inter-firm factors are essential to improve the absorptive capacity and competitive advantages of a firm. It implies that the firm could enhance its competitiveness by making use of the relationship with partners at some specific stages including resources utilizing, knowledge sharing and asset supplementing.

Generally, there is a consensus that absorptive capacity is an important factor that can improve productivity of any firm. However, while some authors only analyze the within-firm structure and mechanism to develop and transfer internal knowledge, some believe that it is more important to analyze the inter-firm mechanism to improve the absorptive capacity of a firm. Respectively, there are many proxies to measure the absorptive capacity of firms. Many papers used R&D – related variables to represent for absorptive capacity, such as R&D intensity (Behera, 2015; Mowery & Oxley, 1995; Tsai, 2001), R&D expenditures (Girma, Gorg, & Pisu, 2008; Silajdzic & Mehic, 2015) or patents (Ahuja & Katila, 2001). However, the findings are not consistent. For instance, Tsai (2001) found that absorptive capacity (proxied by R&D intensity) have positive effect on productivity, meanwhile Mowery & Oxley (1995) also used R&D intensity but concluded that it did not positively influence the external learning capability. Apart from R&D proxies, Martinkenaite & Breunig (2015) used human capital (ratio of white-collar workers to total employment) to represent the absorptive capacity and Flôres, Fontoura, & Guerra Santos (2007), Jabbour & Mucchielli (2007), and Imbriani, Pittiglio, Reganati, & Sica (2011) measured absorptive capacity by the technology gap among firms. The technology gap was presented by TFP, but TPF could include anything but production inputs, such as labor and capital, so that it would not be the best proxy for absorptive capacity.

Absorptive capacity is a broad definition that could include various factors. Hence, attempting to proxy absorptive capacity by considering different parts of it (intra firms and inter firms) seems to have limitations. The author believes that it is better to consider both inter-firms and intra-firms factors when measuring the absorptive capacity of firms. Firstly, the intra-firm factors are included in the capability of firms. The capability here is the internal factors, which are not labor and capital, and the measurement is discussed in detail in the next sections. Secondly, the external factors are examined by considering the gap between domestic firms and foreign firms. The study agrees with the argument that the student firm can learn better from the teacher firm if they are sharing some common knowledge and characteristics. Then, it premises that firms in the same industry could have more chance to learn from each other than from firms in another industry. Therefore, absorptive capacity of a firm is the distance from its firm-specific-capability to the top firm-specific-capability firms in the same industry. Now the question is how to quantify the firm-specific capability. This study suggests that the appropriate proxy could be derived by analyzing the technical efficiency of a firm.

Technical efficiency

Technical efficiency is not a new concept and there are substantial studies estimating this factor for different purposes. Most of them estimated technical efficiency to measure the performance of firms (Farrell, 1957; Badunenko, Fritsch, & Stephan, 2006; Feng & Wu, 2006; Greene, 2005; Ghali & Rezgui, 2011; Battese & Coelli, 1992, 1995, 1988). In Vietnam, there are a few papers on this issue and majority of them attempted to capture the productivity of firms (Minh, Long, & Thang, 2007; H.D. Vu, 2016). Only Vu & Le (2017) use technical efficiency to proxy for absorptive capacity. However, the authors were unable to decompose the technical efficiency that could lead to an upward or downward bias. Based on this idea, the study separates the firm effects, persistent efficiency and time-varying efficiency when calculating technical efficiency.

Firms must transform inputs to outputs by using the "black box" production function. The production function represents the technology to produce final products. If y is m-multidimensional non-negative vector of output and x is n-multidimensional non-negative vector of inputs, the relationship can be presented by the technology function f(.) as follows:

$$y = f(x) \equiv f(x_{1,} \ldots . x_n) \tag{1}$$

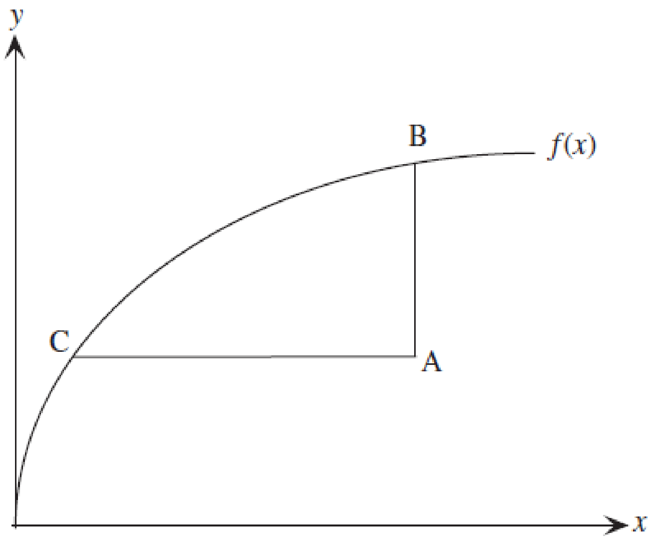
The production function per se describes the maximum amount of outputs produced given certain level of inputs by using current level of technology and it is the frontier of the feasible production set. Therefore, a production plan of any firm is technically inefficient if it is not on the frontier. In the Figure 1, point A is technically inefficient because it is a loss of AB outputs given the same inputs or a waste of AC inputs given the same outputs.

There are two types of technical efficiency: input-oriented and output-oriented technical efficiency. This paper only deals with the second one and it is mathematically presented by:

$$y = f(x) * e^{-u} \tag{2}$$

Where u (positive) is output-oriented technical inefficiency and e^{-u} is technical efficiency. Technical inefficiency could be neutral or non-neutral. If it is non-neutral, it is a function of some factors.

Figure 1. Production function curve



Source: Author

In order to proxy for absorptive capacity, it is necessary to examine technical efficiency in the panel data. One observation can be repeated several times and then panel data allows us to consider heterogeneity. More importantly, the panel data might show if the technical inefficiency is persistent over time or if it is time-variant.

The classic model assumed technical inefficiency is individual specific and time-invariant:

$$y_{it} = f(x_{it};\beta) + \epsilon_{it} \, , \tag{3}$$

$$\epsilon_{it} = v_{it} - u_i, \qquad u_i \geq 0, i = 1, \ldots\ldots, N \;\&\; t = 1, \ldots\ldots, T \tag{4}$$

u_i is time invariant technical inefficiency of individual i and it could be fixed (Schmidt & Sickles, 1984) or random parameter (George E. Battese & Coelli, 1988; S. Kumbhakar, 1987). However, the limitation is the time-invariant assumption. It might make sense in the short period, but it also implies that a firm never learn over years. It is unreasonable in reality. Therefore, Cornwell, Schmidt, & Sickles (1990) put forward the model that includes time-variant factor into technical inefficiency:

$$y_{it} = \alpha_i + x'_{it}\beta + v_{it}, \tag{5}$$

$$\alpha_i \equiv \alpha_{0i} + \alpha_{1i}t + \alpha_{2i}t^2 \tag{6}$$

Where α is firm-specific characteristics and t is changes over time (time trend). Note that in this model, the efficiency of one firm is relative to the efficiency of the best firm in one year. However, because the time trend is treated as independent variable of α_i, it cannot be included in x'_{it}. Therefore, this model does not allow us to separate inefficiency and time trend (or technical change).

Generally, these models could not be split between technical inefficiency and firm heterogeneity, then it might lead to bias in calculating technical efficiency. Additionally, another drawback of the time-variant model is that it is still unable to separate persistent and time-varying inefficiency.

It is desirable to separate firm effects, persistent efficiency and time invariant inefficiency in order to measure absorptive capacity of a firm. Therefore, S. C. Kumbhakar, Lien, & Hardaker (2014) show the model where the error term is broken down into four components: latent heterogeneity μ_i, time-variant inefficiency in short-term uit ,time-invariant inefficiency (persistent inefficiency) ρ_i and random shocks v_{it}. The model is described in detail in the next section. The decomposition is useful and instead of using technical efficiency as a proxy for absorptive capacity, this paper makes use of the availability of persistent (in)efficiency. The component of persistent (in)efficiency is essential in this paper and it is suitable to measure absorptive capacity of a firm. Persistent (in)efficiency represents the management effect and various unobservable inputs that are unlikely to change overtime. It is a good proxy for firm-specific structure and organization, which directly affects the production of a firm. Additionally, persistent efficiency cannot be changed unless there is a big change in the ownership of a firm or a change in institution (such as policy in the industry) (S. C. Kumbhakar, Wang, & Horncastle, 2015, p. 270). Certainly, if it is inefficiency, it will be the internal obstacle, which any firm wants to minimize. However, it does not make much sense if we consider the persistent (in)efficiency of a single firm. It should be the relative one in the industry. Consequently, absorptive capacity of one firm is measured by the gap between the persistent (in)efficiency of one firm and the best firm in the industry.

Note that this study seeks to provide a simplified and generalized version of absorptive capacity measurement, premising that absorptive capacity of one firm is simply the capability gap between this firm and the best foreign firm. This measurement integrates the intra-firm and inter-firm aspects into one proxy of absorptive capacity. Other proxies, including R&D intensity, R&D expenditures, patents or human capital, only reflect the internal capability of firms and do not evaluate much the external interaction of firms. Additionally, although R&D is important, not every firm has enough resources to invest in R&D, especially in the case of less developed or developing countries4. It implies that database is not always available for comparison. Reversely, this proxy based on persistent efficiency can be created for almost all firms with basic data of production inputs, including labor and capital, therefore it is easy to make a comparison across countries. In fact, some papers used the gap in efficiency or TFP to proxy for absorptive capacity (Flôres, Fontoura, & Guerra Santos (2007), Jabbour & Mucchielli (2007), Imbriani, Pittiglio, Reganati, & Sica (2011),H.D.Vu & Le, (2017)) which are quite similar to the method in this paper. However, persistent efficiency can be a better proxy after removing other noises from it.

[4] For example, in case of Vietnam, the database for R&D at firm level is not available continuously in the Annual Enterprises Survey.

This paper deals with the measurement in the case of Vietnam and estimates FDI absorptive capacity of domestic firms in the manufacturing sector. It assumes that the foreign direct investment firms are more advanced, and they are likely to have better absorptive capacity. Therefore, persistent (in)efficiency of the best FDI firms can be a good benchmark. Consequently, FDI absorptive capacity of domestic firms is defined as the gap between their persistent inefficiency and the best FDI firm. According to the author's knowledge, this paper is the first one using the gap in persistent efficiency to represent the absorptive capacity of a firm. Therefore, it is hard to compare it with the exiting literature. Nevertheless, a good proxy must comply with the basic concept of absorptive capacity, then the validity is checked by examining the correlation of this proxy and other common factors/determinants of absorptive capacity from previous studies.

2. Methodology

2.1. Model specification

Follow the equation (3) and after decomposing the error term into four components, the model is presented by:

$$y_{it} = \alpha_0 + f(x_{it};\beta) + \mu_i + v_{it} - \rho_i - u_{it} \tag{7}$$

Where

μ_i is latent heterogeneity and it is independent and identical distribution N (0, δ_μ^2),

ρ_i is persistent inefficiency and it is i.i.d $N^+(0,\ \delta_\rho^2)$,

v_{it} is a random shock to absorb stochastic effects and it is i.i.d $N(0,\ \delta_v^2)$,

u_{it} is time-varying inefficiency in short-term that might not repeat over years and it is i.i.d $N^+(0,\ \delta_u^2)$

Kumbhakar, Wang, & Horncastle (2015) rearrange and estimate the model based on a single stage maximum likelihood method.

$$y_{it} = \alpha_0^* + f(x_{it};\beta) + \alpha_i + \varepsilon_{it} \tag{8}$$

Where:

$$\alpha_0^* = \alpha_0 - E(\rho_i) - E(u_{it}) \tag{9}$$

$$\alpha_i = \mu_i - \rho_i + E(\rho_i) \tag{10}$$

$$\varepsilon_{it} = v_{it} - u_{it} + E(u_{it}) \tag{11}$$

α_i and ε_{it} are distributed $(0,\delta^2)$

x_{it} in this model includes logarithm of capital and labor of the firm i in the Vietnamese manufacturing firms in time t.

y_{it} is logarithm of value added of the firm i in time t.

After conducting some test for identification, the translog production function is preferred to Cobb-Douglas. More specifically, translog is as follow:

$$f(x_{it};\beta) \equiv \beta_{1i} lnk_{it} + \beta_{2i} lnl_{it} + \beta_{3i}(lnk * lnl)_{it} + \beta_{4i}(lnk * lnk)_{it} + \beta_{5i}(lnl * lnl)_{it} \quad (12)$$

It is possible to estimate $\hat{\beta}$ of the model (8) by fixed or random effect with panel data. In this case, the author chooses fixed effect method after conducting the Hausman test. Then $\widehat{\alpha_i}$ and $\widehat{\varepsilon_{it}}$ are predicted. Next, $\widehat{u_{it}}$ the time-varying inefficiency could be estimated by using the equation (11) with assumption on distribution of u_{it}. The residual technical efficiency then is exp($-u_{it}|\varepsilon_{it}$). Then, it is possible to estimate the persistent inefficiency (PI) ρ_i from the equation (10) and persistent technical efficiency is exp($-\rho_i$). Finally, the technical efficiency equals residual technical efficiency times persistent technical efficiency. This method follows the approach of Kumbhakar, Lien, & Hardaker (2014).

Note that this paper focuses on the importance of persistent (in)efficiency and residual (in)efficiency, not the overall technical (in)efficiency. It is expected that in the same industry, the FDI firms are likely to perform better and then the gap between domestic firms and FDI firms is a proxy for absorptive capacity of the domestic firms:

$$DC_{it} = \frac{\max(FPE) - DPE_{it}}{\max(FPE)} \quad (13)$$

DC_{it} is domestic capacity of the domestic firm i in year t, DPE_{it} is persistent efficiency of the domestic firm i in year t and max(FPE) is the maximum value of persistent inefficiency of FDI firm in year t in the same industry. The lower value of DC indicates the better absorptive capacity of the firm.

2.2. Database

Panel data is created from the Annual Vietnamese Enterprises Survey from 2007 to 2015. This period covers many important events from Vietnamese economy. Since 2007, Vietnam has officially joined WTO and has become a potential destination for foreigner investors. Unfortunately, after two years, the global financial crisis occurred and hampered majority of economies worldwide. After 2010, the global economy and Vietnam somehow started recovering from the economic crisis and the business environment has been gradually stabilized. Therefore, performance of firms during this hard time can reflect their capability in the best way.

The panel data includes 52435 observations over eight years and it is unbalanced panel data. Data summary is in the Appendix C.

From the Annual Vietnamese Enterprises Survey, some major variables are taken. K is fixed capital for production of a firm (million VND), L is total labor for production of this firm (person) and Y is value added of the firm (million VND) which is calculated by income approach. During the period from 2007 to 2015, only firms that appear at least 7 times are chosen to avoid the interruption of the database. All variables are transformed by using a logarithm.

3. Findings and discussions

Before estimating efficiency, it is necessary to conduct some specification tests, including the test for the form of production function (Cobb-Douglas or Translog production function), the test for time-variant inefficiency vs. time-invariant inefficiency and the test for fixed effect vs. random effect method. The maximum likelihood test results in the Table 1 show that the translog production function, time-variant efficiency are preferred over Cobb-Douglas and time-invariant and the Hausman test reveals that fixed effect model is better than random effect in this model (Table 2).

At the first stage, the model (8) is regressed by using fixed effect with panel data (find table of result in the Appendix A). Then, persistent efficiency and residual efficiency are estimated based on the method of Kumbhakar, Lien, & Hardaker (2014). Note that the study only focuses on these two factors rather than the overall technical efficiency because the gap in persistent efficiency between domestic firms and foreign firms is defined as absorptive capacity of the former.

Table 1. Maximum likelihood test

H_0	Test statistic	Critical value	Decision
Cobb-Douglas ($\beta_3 = \beta_4 = \beta_5 = 0$)	28.66077	6.483	Reject
Time invariant ($\delta_u = 0$)	2138.3768	3.841	Reject

Source: Author

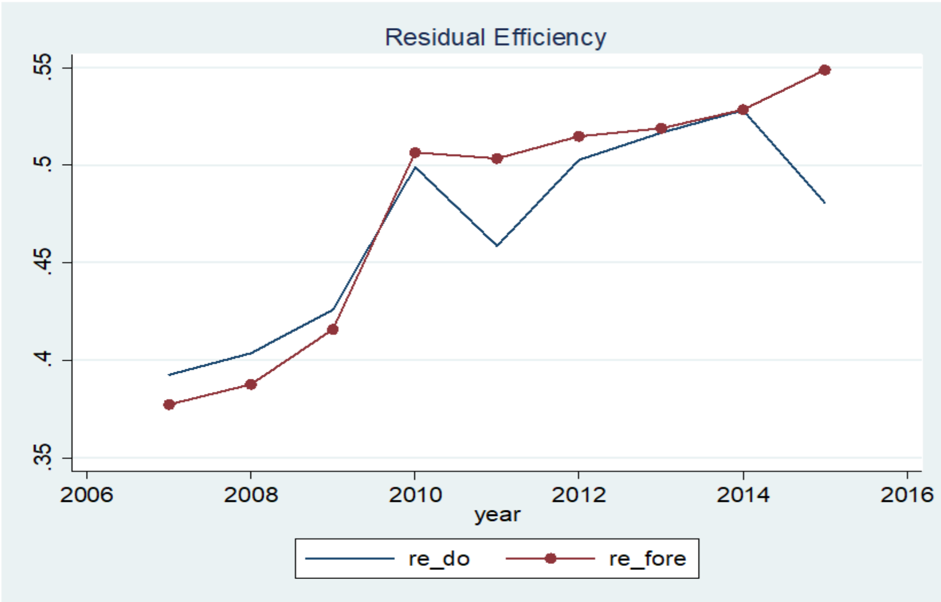
Table 2. Hausman test

H_0	Hausman test	Critical value	Decision
Random effect	666.98	11.07	Reject

Source: Author

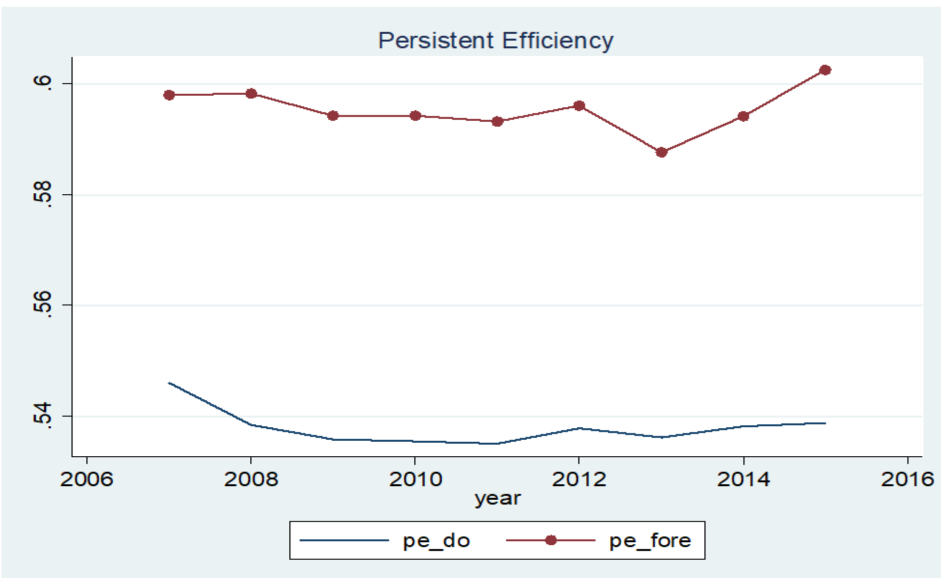
It can be noticed easily from the Figure 2 and Figure 3 that the difference between domestic group and foreign group in residual efficiency is not significant. However, while RE of foreign firms tends to increase gradually over years, RE of domestic firms fluctuates around 50% after an increase from 2007 to 2010. Nevertheless, the RE is only a short-term efficiency and it may not repeat next year for one firm. For instance, one firm receives a huge bonus from lottery and the director decides to use this amount to invest in production. This amount could boost the production in this year but next year the same thing is unlikely to occur. Reversely, persistent efficiency (PE) is unlikely to change unless there is a big change for the whole industry or a change in the ownership or management mechanism of a firm. Interestingly, PE of the foreign group is considerably higher than in the case of the domestic group. From 2007 to 2015, the average PE of foreign firms is 59.53% and in the case of domestic firms it is only 53.7%. It means that the efficiency difference between the two groups lies on the persistent efficiency. Recall that this indicator is unlikely to change, and it repeats over years. It might imply that a big change in management system of domestic firms is needed to help them converge to the frontier in the industry.

Figure 2. Residual efficiency



Source: Author

Figure 3. Persistent Efficiency



Source: Author

Then, the PE gap between domestic firms and the best FDI firm could be a proxy for absorptive capacity. The DC of domestic firms is calculated in the equation (13). The manufacturing sector of Vietnam comprises of 23 sub-sectors and the Table 3 presents the mean value of DC of them:

Table 3. Average DC of sub-sectors

Sub-sector	Domestic observation	Mean DC over years	rank	Technology[5]
Manufacture of tobacco products	83	0.0889	1	Low
Manufacture of coke and refined petroleum	34	0.1318	2	Medium
Manufacture of electrical equipment	984	0.2175	3	Medium
Manufacture of machinery and equipment n.e.c	1414	0.2591	4	Medium
Manufacture of pharmaceuticals, medicinal	504	0.2606	5	High
Manufacture of chemicals and chemical products	1975	0.2744	6	Medium
Manufacture of motor vehicles; trailers and semitrailers	267	0.2786	7	Medium
Manufacture of basic metals	764	0.2908	8	Medium
Manufacture of rubber and plastics products	4928	0.2978	9	Medium
Manufacture of textiles	2444	0.3134	10	Low
Manufacture of computer, electronic and optical	432	0.3329	11	High
Manufacture of furniture	1762	0.3368	12	Low
Manufacture of fabricated metal products, except	5121	0.3513	13	Medium
Manufacture of paper and paper products	2262	0.3539	14	Low
Repair and installation of machinery and equipment	521	0.3715	15	Medium
Manufacture of other transport equipment	398	0.3725	16	High
Manufacture of leather and related products	1314	0.3751	17	Low
Other manufacturing	940	0.3770	18	Medium
Manufacture of other non-metallic mineral products	1875	0.3839	19	Medium
Manufacture of food products	6124	0.3898	20	Low
Printing and reproduction of recorded media	3466	0.4064	21	Medium
Manufacture of wearing apparel	4511	0.4242	22	Low
Manufacture of wood and of products of wood and	1658	0.4369	23	Low
Manufacture of beverages	1313	0.5099	24	Low

Source: Author

Among these sub-sectors, the manufacture of tobacco products seems to have the best absorptive capacity (with lowest value of average DC over year). The second place is the manufacture of coke and refined petroleum. The following ranks are the equipment-related sub-sectors. Interestingly, some important sub-sectors in Vietnam, such as

[5] Eurostat classification

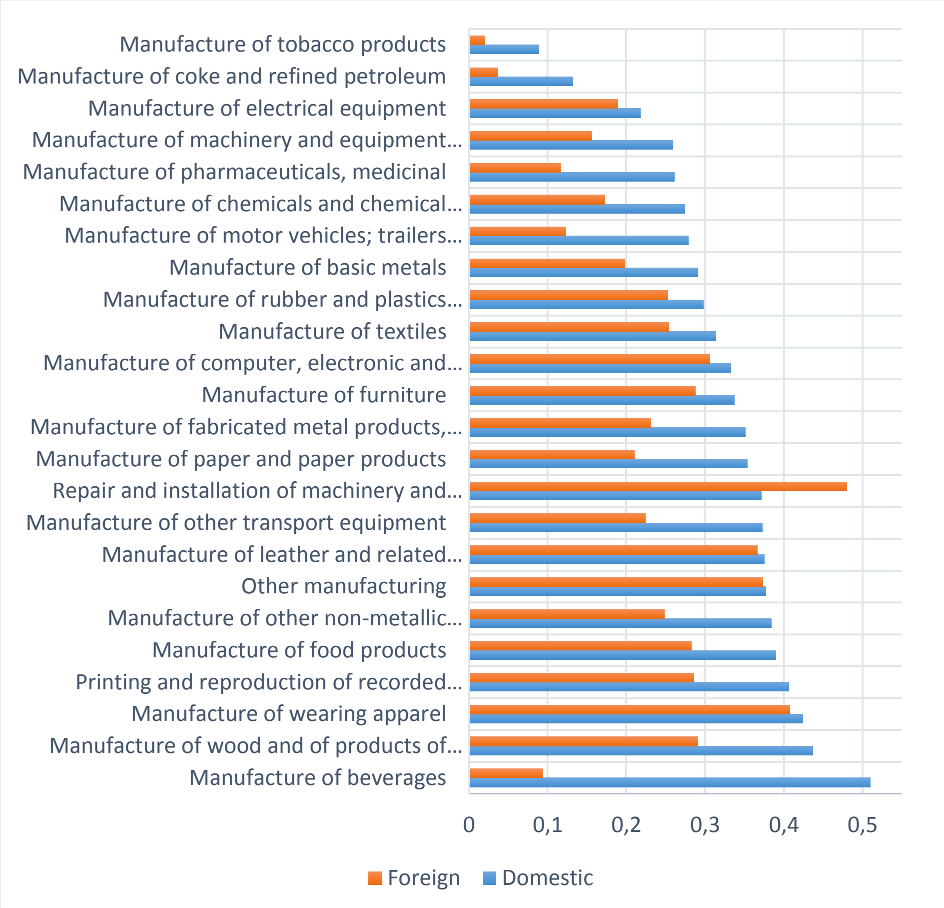
textiles and wearing apparel (H.D. Vu, 2016), do not have a good absorptive capacity from 2007 to 2015. Meanwhile, absorptive capacity of the manufacture of motor vehicles, trailers and semitrailers is good with the average DC of 0.2786 (rank 7th). Interestingly, among the top 5 sub-sectors, there are four with medium to high technology level, while among the bottom 5, there are four sub-sectors with low technology level. It implies that firms in the more advanced-technology sub-sectors have better chance to learn from foreign firms. This coincides to some extent with the argument of Cohen and Levinthal (1994) that absorptive capacity depends on the prior knowledge of firms. The firms in the medium and high technology sub-sectors obviously accumulate better knowledge than others and then they could gain more benefits from foreign counterparts. Reversely, the firms in the low technology sub-sector might struggle to learn due to the poorer accumulated knowledge.

Although the main purpose of the paper is to measure the FDI absorptive capacity of domestic firms, it is interesting to compare it with the absorptive capacity of foreign firms in the same industry. The absorptive capacity of one foreign firm is the gap in PE between this firm and the best foreign firms in the same industry. It refers to the benefits this foreign firm can gain from the top foreign firm. From the Figure 4 we can see that the mean values of DC across all subsectors of foreign firms are always smaller than these of domestic firms (except for the subsector of Repair and installation of machinery and equipment). It implies that absorptive capacity of foreign firms in the manufacturing sector of Vietnam is better than in the case of domestic firms. The difference in the absorptive capacity between domestic and foreign groups might imply a risk for Vietnam's economy. If one foreign firm and one domestic firm learn from the best foreign firm at the same time, the foreign one might gain more benefit due to better absorptive capacity and consequently it can generate more knowledge and products than the domestic one. It means the gap can be larger and larger over years and the domestic sectors are unlikely to compete with the foreign sectors. However, this paper can only show the phenomenon and further study is needed to conclude this issue.

Unfortunately, there is a lack of studies using this method to measure absorptive capacity, hence it is hard to make a comparison on the proxy. Therefore, in order to check the validity of this proxy, the study takes one further step by examining the correlation between this proxy and other relating factors. The key point is that if this is a good proxy of the absorptive capacity of a firm, it should have positive correlations[6] with some important factors which are stated in the previous studies. Various authors argue that absorptive capacity is accumulative. Cohen & Levinthal (1994) show that cumulativeness is an essential feature of absorptive capacity. The current absorptive capacity of a firm depends on what it has learned before and the future absorptive capacity depends on what it is learning at the moment.

[6] Note that, because the lower value of DC implies that better absorptive capacity, the positive correlation here turns out to be negative correlation.

Figure 4. Mean DC of domestic and foreign firms



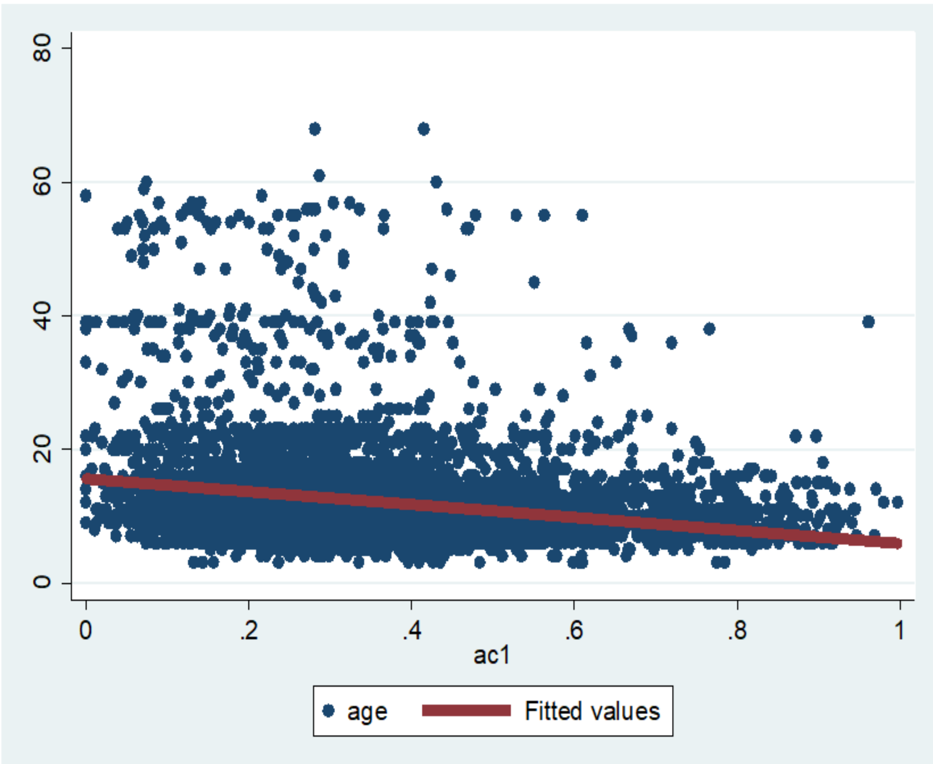
Source: Author

It implies that there is a positive correlation between absorptive capacity and the age and size of a firm (Mowery & Oxley, 1995; Rao & Drazin, 2002; Sørensen & Stuart, 2000). Additionally, absorptive capacity of a firm differs due to different absorptive capacity of individual members (Cohen & Levinthal, 1994) and therefore firms with bigger number of skilled-workers might have better absorptive capacity (Martinkenaite & Breunig, 2015). And certainly, it is expected that a firm that is technologically more advanced could absorb new knowledge faster. Therefore, the association between absorptive capacity and age and size of a firm, skill of its workers and its technological level is expectedly positive. Consequently, a good proxy of absorptive capacity should have the same correlations, otherwise it is unable to be used in further studies. These correlations are examined in the case of Vietnam.

Absorptive capacity and age and size of a firm

Correlation between absorptive capacity and age of a firm in the Vietnamese manufacturing sector is significantly negative (correlation is -0.2251). This correlation is shown in the Figure 4. Note that the lower value of DC is, the better absorptive capacity of the firm is. Therefore, it captures a phenomenon that the more experienced firms seems to have better learning capability. Cohen & Levinthal (1994) argue that pre-knowledge is important for absorptive capacity and knowledge could be cumulated over times. Firms operating longer in one industry certainly have a better chance to gain more knowledge and consequently, their absorptive capacity is better. This argument is to some extent approved in this case.

Figure 5. Correlation between DC and age of a firm



Source: Author

Similarly, the correlation between size of a firm and absorptive capacity of a Vietnamese firm is positive. The small firms have the biggest average DC over year, whereas the large firms possess the lowest one. It implies that absorptive capacity of the large firms is better than in the case of the small firms. Importantly, the difference between the small firms and the large firms is significant (0.368 comparing to 0.266). Interestingly, the medium-sized firms have quite good absorptive capacity with the value of 0.270 (Table 4).

Table 4. Average DM of different sized-firms

Variable	Obs	Mean	Std. Dev.
Small	40,433	0.3684	0.1617
Medium	1,443	0.2709	0.1734
Large	3,218	0.2668	0.1854
Average AC	45,094	0.3580	0.1667

Source: author

More than 45000 firms are grouped into three groups: small, medium and large based on the number of workers. Then, mean difference between these groups is tested by using one-way analysis of variance (one-way ANOVA) and the result shows that mean difference among these groups is not coincident (Table 5).

Table 5. Annova test for mean difference

Source	Sum of square	df	Mean square	F	Prob > F
Between groups	42.1153	2	21.0576	783.99	0.0000
Within groups	1211.125	45091	0.0269		
Total	1253.24	45093	0.0278		
Bartlett's test for equal variances: chi2(2) = 130.4066 Prob>chi2 = 0.000					

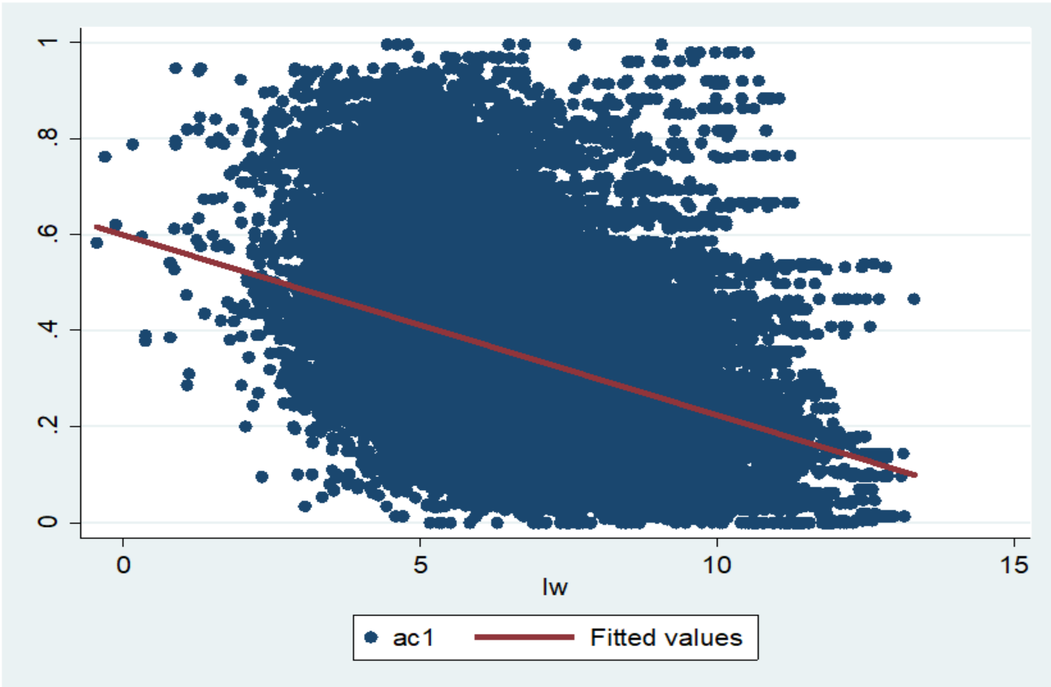
Source: author

Absorptive capacity and skilled workers

The prerequisite of absorptive capacity is the pre-knowledge of an individual and an organization. Within a firm, a worker with higher skills certainly possesses more knowledge than those with low skill level. Normally, the skill of a worker is measured by education attainment or education degree. Unfortunately, this data is not available, hence, the wage of workers is used instead. It is argued that high-skilled workers can receive higher wage due to their better contribution to the firm. Therefore, higher wage can be interpreted as higher skill.

Once again, the measurement of absorptive capacity seems appropriate when the correlation between absorptive capacity and labor skill is significantly negative (Figure5). The lower value of average DC (the higher absorptive capacity) is, the higher skill of worker in domestic firms and vice versa. Note that this is only correlation that helps us see the phenomenon and it is not regression, so it is not possible to conclude if a high-skilled worker leads to better absorptive capacity or if good absorptive capacity leads to high-skilled individuals.

Figure 6. Correlation between DC and wage



Source: Author

Absorptive capacity and technology level

Essentially, the relationship between R&D activities and absorptive capacity is trivial. R&D investment can positively affect capability of a firm to realize and apply new knowledge into practice. Basically, R&D directly relates to technology level of a firm. However, data on R&D and technology level of a Vietnamese firm in manufacturing sector is not possible to collect. Therefore, the study must find another proxy. It is premised that firms that use their own websites are more technologically advanced than those firms that do not. Consequently, the domestic firms are categorized based on whether they do or do not use websites and then their absorptive capacity is compared. This method is unable to capture entirely the correlation between absorptive capacity and technology level but to some extent it could be a good signal for it. Due to the lack of database, the paper uses website existence to assess the technology level of firms, however, it is necessary to use other criteria in further studies.

Table 6. Average DC of using and non-using website domestic firms

Variable	Obs	Mean	Std. Dev.
Using web	4,177	0.2429	0.1568
Non-using web	20,816	0.3416	0.1603

Source: Author

In the Table 6, there can be seen a difference between web-using firms and firms that do not use websites. The average value of the former is lower than in the case of the latter and it indicates that absorptive capacity of the web-using ones is better. Implicitly, the result indicates that there is a correlation between technology level and absorptive capacity of Vietnamese manufacturing firms. It can be noticed that high-tech firms might absorb external knowledge better than low-tech firms. This difference is tested by t-test and the result confirms that the mean difference is significant (Table 7).

Table 7. t-test for mean difference

Source	Sum square	df	Mean square	F	Prob > F
Between groups	33.9411	1	33.9411	1330.78	0.000
Within groups	637.3872	24991	0.0255		
Total	671.3283	24992	0.0268		

Source: Author

Generally, it seems that the measurement of a firm's absorptive capacity based on the gap in persistent efficiency is reliable at least in the case of Vietnam when the expected correlations are approved. Therefore, it is claimed that this proxy for absorptive capacity can be used in the following studies in the case of Vietnam. However, duplicating is needed in other countries to improve the reliability.

4. Conclusion

There are substantial studies on absorptive capacity at the firm level and consequently there are various measures of absorptive capacity. However, finding a comprehensive proxy for it is difficult because different authors might look at different aspects of absorptive capacity. Approaches on absorptive capacity might vary but all of them to some extent converge to the point that: absorptive capacity of a firm is the internal capability and it also depends on external environment. Based on this, the present study attempts to simplify the measurement by defining absorptive capacity of a firm as a gap in persistent efficiency between this firm and the best firm in the same industry (normally the best one is a foreign one) and apply it to the case of Vietnamese manufacturing firms from 2007 to 2015. Persistent inefficiency is time-invariant and can repeat over times. It is unlikely to change unless there is a change in the firm's management mechanism (S. C. Kumbhakar et al., 2015). Hence, it can be a good proxy for the internal capacity of a firm. Among 23 sub-sectors of the Vietnamese manufacturing sector, the result shows that the domestic firms in the manufacture of tobacco product have the best absorptive capacity while firms that manufacture beverages do not have a good absorptive capacity. However, according to the author's knowledge, there is a lack of studies using the same method to proxy for absorptive capacity, therefore it is not possible to make a comparison. Consequently, the validity of the measurement is tested by considering the correlation between absorptive capacity and other-relating factors, including age and size of a firm, its technological level and the level of skill of its workers. All the correlations correspond with the expectations, hence this measurement to some extent could be a solid proxy for absorptive capacity at firm level. Due to insufficient data, one limitation of the paper is its dependence on the existence of firms' websites in order to evaluate their technological level. For further research, it is needed to find another proxy. Finally, the study has not figured out the casual relationship between absorptive capacity and above-mentioned factors and it is better to apply this method to some other cases to improve the validity.

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Appendix A. Fixed effect regression

R-square:	Number of Obs = 52435
Within = 0.1256	
Between = 0.8055	
Overall = 0.6006	
	F(5,45864) = 1317.56
Corr(u_i, X) = 0.3075	Prob > F = 0.0000

LnY	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
LnL	0.5681	0.0318	17.84	0	0.5057	0.6305
LnK	0.2811	0.0274	10.23	0	0.2272	0.3349
LnL*LnL	0.0232	0.0051	4.53	0	0.0132	0.0333
LnK*LnK	-0.0024	0.0024	-0.98	0.329	-0.007	0.0024
LnL*LnK	-0.009	0.0053	-1.84	0.066	-0.0201	0.0006
cons	4.3966	0.0985	44.62	0	4.2035	4.5898
sigma_u	0.8529					
sigma_e	1.2129					
rho	0.3309	(Fraction of variance due to u_i)				

Source: Author

Appendix B. Number of domestic and foreign firms over year

Name of industry	Domestic observation	Foreign observation
Manufacture of food products	6,124	650
Manufacture of beverages	1,313	86
Manufacture of tobacco products	83	8
Manufacture of textiles	2,444	486
Manufacture of wearing apparel	4,511	1,394
Manufacture of leather and related products	1,314	548
Manufacture of wood and of products of wood and	1,658	164
Manufacture of paper and paper products	2,262	277
Printing and reproduction of recorded media	3,466	84
Manufacture of coke and refined petroleum	34	15
Manufacture of chemicals and chemical products	1,975	388
Manufacture of pharmaceuticals, medicinal	504	43
Manufacture of rubber and plastics products	4,928	1,019
Manufacture of other non-metallic mineral products	1,875	165
Manufacture of basic metals	764	54
Manufacture of fabricated metal products, except	5,121	696
Manufacture of computer, electronic and optical	432	272
Manufacture of electrical equipment	984	213
Manufacture of machinery and equipment n.e.c	1,414	79
Manufacture of motor vehicles; trailers and semitrailers	267	92
Manufacture of other transport equipment	398	136
Manufacture of furniture	1,762	159
Other manufacturing	940	293
Repair and installation of machinery and equipment	521	20

Source: Author

Appendix C. Variables summary

	2007		2008		2009		2010		2011		2012		2013		2014		2015	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
LnY	4,834	8.1415	5,483	8.1232	6,222	8.1588	6,301	8.5750	6,132	8.2974	5,890	8.5194	6,018	8.4569	6,030	8.53299	5,525	8.4501
LnL	4,834	3.6278	5,483	3.5429	6,222	3.4540	6,301	3.4649	6,132	3.4610	5,890	3.3775	6,018	3.2939	6,030	3.3014	5,525	3.2940
LnK	4,834	7.4118	5,483	7.4338	6,222	7.4177	6,301	7.6886	6,132	7.2699	5,890	7.5014	6,018	7.5297	6,030	7.5229	5,525	7.8248
LnL*LnL	4,834	15.9288	5,483	15.2021	6,222	14.5069	6,301	14.575	6,132	14.5962	5,890	14.1007	6,018	13.7269	6,030	13.9911	5,525	13.9338
LnK*LnK	4,834	59.5264	5,483	59.2604	6,222	58.8712	6,301	62.878	6,132	57.6604	5,890	60.2353	6,018	60.5325	6,030	60.7215	5,525	65.21101
LnL*LnK	4,834	29.5225	5,483	28.7759	6,222	27.8840	6,301	28.8857	6,132	27.6888	5,890	27.7078	6,018	27.18201	6,030	27.5042	5,525	28.2762

Source: Author