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Productivity and Timing of Foreign Direct Investment: Evidence Based on Korean Direct Investment in China

Sangho Kim*

This study investigated the value of waiting with regard to firms' decision-making about foreign direct investment (FDI) in the context of productivity. To this end, a Cox (1972) proportional hazards model was applied to FDI data gathered from Korean manufacturing firms in China. Empirical results reveal that firms with average production led FDI, followed by more productive firms (which delayed their FDI to lower the probability of FDI failure) and by less productive firms (which had insufficient resources to implement such investment). The findings suggest that FDI delay time is a non-linear function of a firm's productivity. Industry-wide regression analysis of two industries showed that the results held for the chemical industry.

Key Words: FDI, Value of Waiting, Cox Proportional Hazards Model
JEL Classification: G30, D80, F10

* College of International Management, Ritsumeikan Asia Pacific University, 1-1 Jumonjibaru, Beppu, Oita 874-8577, Japan. Email: shkim@apu.ac.jp, Telephone: +81-977-78-1259, Fax: +81-977-78-1123.

Ⅰ. Introduction

When implementing foreign direct investment (FDI), firms must bear considerable initial sunk costs and great risk in terms of expected profits because of limited information about foreign markets. Therefore, some studies have focused on the value of waiting, in addition to the net present value of foreign investment [Dixit (1992), Dixit and Pindyck (1994), McDonal and Siegal (1986), Trigeorgis (1996)]. Research has shown that delaying irreversible foreign investments enhances the probability of FDI success under conditions of uncertainty because the delay provides firms with more time to collect information and build an appropriate supply network [Guiso and Parigi (1999), Leahy and Whited (1996)].

Bell and Campa (1997) and Campa (1994) analyzed how exchange rate uncertainty affected firms' decisions to delay entering a foreign market. Rajan and Marwah (1998) demonstrated that under conditions of policy-oriented uncertainty, firms were likely to postpone foreign investments until they were confident about the credibility of a host country's government. Rivoli and Salorio (1996) and Trigeorgis (1996) investigated how uncertainty affected FDI timing using an option theoretic framework and found that the value of waiting decreased with increased competitive pressure. Thus, firms tended to invest earlier if they had insufficient market power to withstand competition or if they faced severe competition in a foreign market.

This study investigated the value of waiting with regard to firms' decision-making about FDI under conditions of uncertainty within the context of productivity. Quality control is a critical product-specific risk associated with foreign operations because potential investment failure could substantially erode expected FDI profits. This risk is particularly threatening for firms that produce sophisticated products using advanced complex technologies, which require not only quality parts and components but also skilled workers. Firms with higher productivity have a higher probability of FDI failure: more productive firms use more advanced production technologies, making it difficult for the firms to ensure the quality of goods produced abroad. Therefore, more productive firms are more likely than less productive firms to delay investment in foreign markets, both to ensure the development of an appropriate production network in the host country and to gather more data

to ensure investment projects are prudent.

However, less productive firms will not necessarily initiate a foreign investment earlier than more productive firms because they often lack the competitiveness and resources to move abroad. Thus, firms with intermediate productivity appear to be more likely to execute foreign investments earlier than firms with relatively high or relatively low productivity. Under this hypothesis, FDI delay time should be a non-linear quadratic function of the firm's productivity: increased productivity will shorten FDI delay time until reaching an average productivity level, after which delay time will lengthen. This study tested the validity of the hypothesis by applying a Cox (1972) proportional hazards model to Korean manufacturing firms' FDI in China, the country with the largest portion of Korean FDI.[1)]

Most previous studies have reported that productivity has a positive effect on FDI decision-making, as more productive firms are better able to bear irreversible sunk costs and investment risks associated with FDI than are less productive firms. Antras and Helpman (2004) argued that more productive firms tend to use factor inputs from the foreign country because they are able to compensate for the costs of establishing foreign affiliates. Helpman, Melitz, and Yeaple (2004) developed a theoretical model in which the threshold of productivity is greater among FDI firms than among export-based and domestic firms. Kimura and Kiyota (2006) reported that more productive firms are more likely than less productive firms to use FDI, based on Japanese firm-level panel data. Raff and Ryan (2008) also found that among Japanese firms, increased productivity hastened a firm's first FDI and had a positive influence on consecutive investments. Tomiura (2007) demonstrated that among American firms, productivity levels were highest among FDI firms, followed by exporting firms, and finally domestic firms.

In contrast, other studies have produced results that are not based on a simple positive relation between productivity and FDI. Chang and Lu (2006) demonstrated that firms with intermediate productivity levels were the first to migrate, and that the most productive and least productive firms tended to lag behind. Head and Ries (2003) argued that the least productive firms will execute FDI if the host country is small and yields a comparative advantage

1) For example, about half of the 15,192 Korean FDIs from 1995-2003 were in China; of those, 83.6% were manufacturing investments.

with regard to a specific factor because less productive firms tend to use factor inputs that are abundant and inexpensive in the foreign country. Ito (2007) found that productivity did not affect firms' FDI decision-making in the manufacturing sector, although it had a positive effect on FDI in the service sector.

This study expanded on the research outlined above, analyzing how productivity affects the likelihood of FDI based on the timing of each firm's first investment decision. In contrast to most previous studies, which have restricted the relation between productivity and FDI timing to a linear form, this study was based on the hypothesis that firms with intermediate productivity tend to execute their first investment earlier than firms with relatively high or relatively low productivity. Specifically, it assessed how productivity affected firms' first FDI in China based on Korean manufacturing data from 1988-2005; the Cox (1972) proportional hazards model was used to determine how firm-specific factors affected the likelihood of investment at each stage.

Section 2 of this paper describes the study methodology and data. Section 3 reports the empirical findings about the relationship between productivity and FDI timing. Section 4 provides conclusions and discusses policy implications based on the main empirical findings.

Ⅱ. Methodology and Data

1. Methodology

To investigate how firm-specific factors affected the likelihood of investment at each stage, this study applied the Cox (1972) proportional hazards model. This semi-parametric partial likelihood model can model the effects of the explanatory variables parametrically, without requiring a parametric functional form for duration dependence. It is expressed as

$$h_i(t \mid x) = h_0(t)\exp(x_i \beta_x) \tag{1}$$

where x_i captures the effects of firm *i*'s firm-specific characteristics that influence investment likelihood; $h_0(t)$ is the "baseline" hazard function, which represents the hazard rate for each firm when all independent covariates are set to 0; and $h_i(t)$ is the proportion of $h_0(t)$ determined by the effects of applicable explanatory variables. Firm-specific characteristics that positively influence investment are associated with improved investment hazards, corresponding to greater likelihood of investment, whereas variables that negatively influence investment likelihood are associated with worse investment hazards.

2. Data

This study used data combined from two datasets: financial statement data and foreign direct investment data. The former was obtained from the Korean Information Service's KIS-VALUE database, which includes data on the financial status of all companies listed on the Korean Stock Exchange; and the latter was provided by Overseas Direct Investment Information, as compiled by Korea Eximbank.

The sample firms were all 422 Korean manufacturing firms listed on the stock exchange throughout the sampling period of 1988-2005, and their investments in China were traced using the FDI database. The sample included firms that made direct investments in China when it liberalized in 1988, as well as those that did not invest until 2005. Thus, the dataset is right censored. Balance sheets and income statements from KIS-VALUE were used to estimate productivity and to compile other control variables.

In the model, capital stock (K) is the real amount of tangible fixed assets. Labor input (L) can be proxied by the number of workers, and real value-added (VA) can be used for output. Labor costs (C_L) consist of employee remuneration including wages, bonuses, retirement compensation, and other welfare costs. Capital costs (C_K) are calculated as a sum of interest payments, rent, and depreciation costs. Total costs (C) are calculated as a sum of these factor costs ($C = C_L + C_K$), and a factor's share in the total costs ($S_L,\ S_K$) is calculated as the factor's share of the total costs ($S_j = C_j / C,\ j = L,\ K$).

According to Nadiri and Sickles (1999) and Aw, Chen, and Roberts (2001),

firm-level total factor productivity growth ($\dot{TFP}$) can be estimated using the chained-multilateral index number approach. This approach uses a separate reference point for each cross-section of observation and then chain-links the reference points together by year, as in the Tornqvist-Theil index. Output, input, and productivity level for each plant in each year can thus be measured relative to a hypothetical plant at the base time period. This approach enables transitive comparisons of productivity levels between observations in panel data. The productivity index for firm *i* with output Y_{it} and input $X_{jit}(j = L, K)$ at time $t(= 1, 1, \ldots, T)$ can be measured as

$$\begin{aligned}\ln TFP_{it} = (\ln Y_{it} - \overline{\ln Y_t}) + \sum_{t=2}^{T}(\overline{\ln Y_t} - \overline{\ln Y_{t-1}}) \\ - \left\{ \sum_j \frac{1}{2}(S_{jit} + \overline{S_{jt}})(\ln X_{jit} - \overline{\ln X_{jt}}) \right\} \\ + \sum_{t=2}^{T}\sum_j \frac{1}{2}(\overline{S_{jt}} + \overline{S_{jt-1}}\,(\overline{\ln X_{jt}} - \overline{\ln X_{jt-1}}) \Bigg\} \end{aligned} \quad (2)$$

where bars represent averages of the variables.

In estimation, three-year-average productivity growth ($\overline{TFP}$) until FDI was officially permitted in China is used to estimate productivity. To control firm-specific differences that could affect a firm's investment decision-making, the model includes firm size, represented either by output (Y) or number of employees (L), firm age (*Age*) by years from foundation to FDI liberalization, and exports (*Exp*).

All nominal values were set using 2000 constant prices, based on various deflators including GDP deflators by industry, GDP deflators for capital formation, and export price index. Table 1 lists sample means and standard deviations for all variables. For individual industry estimation, sample firms were classified into double-digit industries according to the International Standard Industry Classification (SIC). The chemical industry was represented by SIC 35 (chemical, petroleum, and coal products) and the fabrication industry by SIC 38 (fabricated metal products, machinery, and equipment).[2)]

2) Only these two industries were estimated separately because other industries had an insufficient degree of freedom to produce significant results.

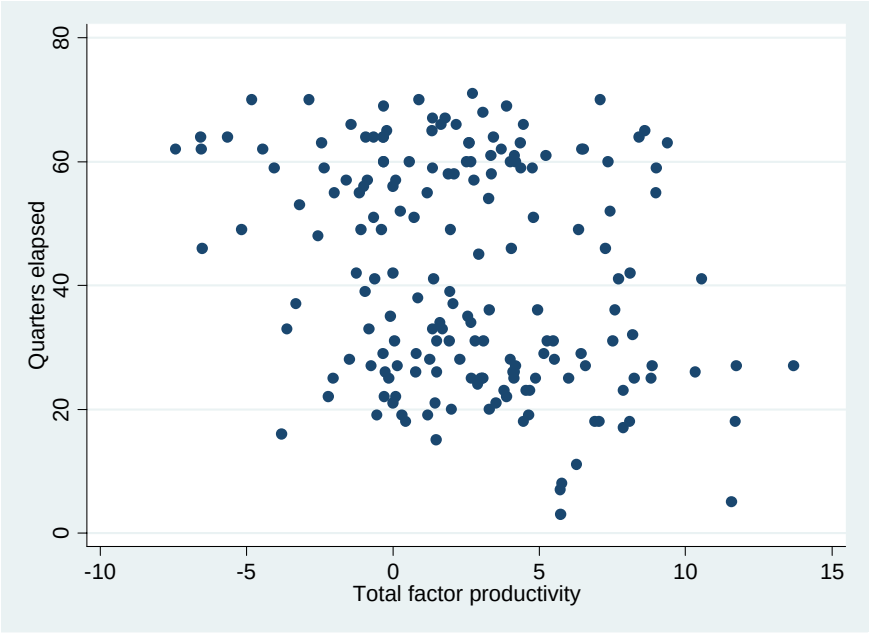
<Table 1> Descriptions, Abbreviations, Means, and Standard Deviations for Variables Related to the Timing of FDI in China by Korean Manufacturing Firms

Variable	Description	Mean (SD)
Number of Observations (N)	Number of sample firms	422
Number of investing firms	Number of firms that invested in China during the sampling period, 1988-2005	180
Number of quarters elapsed (QFDI)	Quarters elapsed while the Korean firms implemented their first FDIs in China after this was officially permitted in 1988.	41.81 (18.02)
Average growth of TFP ($\overline{TFP}$)	Average growth rate of TFP for the three years before FDI in China by Korean firms was allowed in 1988	0.4620 (1.2779)
Real Output (Y)	Real value of output before FDI in China by Korean firms was allowed in 1988	2160080 (6212091)
Number of employees (L)	Number of employees before FDI in China was permitted	1539.078 (3303.435)
Firm's age (Age)	Firm's age from foundation to the year FDI was allowed	21.45 (11.61)
Real value of exports (Exp)	Real value of exports before FDI in China was permitted	4219.875 (32519.6)

Notes: All nominal units are in 2000 constant prices and billion Korean Won (about million US$).

The scatter plots in Figure 1 show the number of quarters elapsed (vertical axis) while the Korean firms implemented their first FDIs in China after this was officially permitted in 1988 in relation to the three-year-average TFP growth rates of firms (horizontal axis) before the FDI permission. The plots indicate that TFP and FDI timing had a non-linear relationship: firms with intermediate productivity levels tended to undertake FDI earlier than did the most productive or least productive firms. The plots also show that earlier migration appeared to stimulate later migration, as FDI expanded exponentially over time. This preliminary evidence is investigated in more detail in the next section.

<Figure 1> Number of quarters elapsed (vertical axis) while the Korean firms implemented their first FDIs in China after this was officially permitted in 1988, and the three-year-average TFP growth rates of firms (horizontal axis) before the FDI permission



Ⅲ. Empirical Results

Table 2 lists coefficient estimates for Korean FDI in China after 1988. The estimates were produced using the Cox proportional hazards model to assess FDI delay times for firms' first FDI. A total sample model was estimated in addition to two other industry models (chemical and fabricated metal industries). Independent variables included three-year-average productivity growth ($\overline{TFP}$) and the square term of productivity growth ($\overline{TFP}^2$) as basic explanatory variables, along with firm size (output, Y, or number of employees, L), exports (Exp), and *Age* as control variables.

Table 2: Coefficient estimates according to the Cox (1972) proportional hazards model for the timing of FDI in China by Korean manufacturing firms after this was officially permitted (Analysis time: number of quarters elapsed)

Explanatory Variables	Total Sample		Chemical		Fabricated metal	
	Basic model	Chosen model	Basic model	Chosen model	Basic model	Chosen model
$\overline{TFP}$	0.2380* (0.0769)	0.4355* (0.1007)	0.3363* (0.1498)	0.6914* (0.2758)	0.3750* (0.1298)	0.3562* (0.1532)
$\overline{TFP}^2$		-0.1106* (0.0417)		-0.2051** (0.1185)		0.0160 (0.0714)
L	0.00003*** (0.00002)	0.00009* (0.00002)	0.0001* (0.00007)	0.0002* (0.00009)		
Y					0.0450** (0.0212)	0.0419*** (0.0267)
Exp	0.0060 (0.0499)	-0.0085 (0.0482)	0.0970 (0.2402)	0.0184 (0.2432)	-0.1256** (0.0709)	-0.1265** (0.0715)
Age	-0.0065 (0.0066)	-0.0106*** (0.0070)	-0.0077 (0.0130)	-0.0166 (0.0142)	-0.0078 (0.0130)	-0.0070 (0.0135)
LL	-1023.31	-1019.42	-195.64	-193.97	-292.51	-292.48
x^2	41.36*	49.14*	20.56*	23.89*	24.79*	24.84*
Link-test statisic	0.7220* (0.1255)	0.0254 (0.0746)	0.6824* (0.2082)	0.0261 (0.1672)	0.9510* (0.1085)	-0.0662 (0.1213)
N	422 (180)		111 (46)		129 (67)	

Notes: Standard errors in parentheses. * (**,***) denotes statistically significant at the 1 (5, 10) % significance level. Numbers in parentheses after numbers of sample firms represent the numbers of firms that invested in China during the sampling period, 1988-2005.

Of the independent variables, two productivity variables were used to test the hypothesis that Korean firms with higher productivity are at greater risk of failure than firms with average or lower productivity and thus tend to wait longer to invest in China. The hypothesis is based on the theory that more productive firms tend to require more time to assess the market environment in a host country, and to wait for industrial development to support their sophisticated production process.

Other explanatory variables controlled for firm size and business experience, as these might explain a firm's ability to mobilize resources and evaluate a foreign investment project before undertaking it. Increased firm size and experience were expected to reduce the waiting time for FDI.[3)]

First, a basic model was developed, including only single terms for all explanatory variables. Next, link testing was conducted for the revised Cox proportional model, based on predicted values from the original Cox model:

$$h_i(t \mid x) = h_0(t)\exp[\beta_1(x\hat{\beta}_x) + \beta_2(x\hat{\beta}_x)^2] \quad (3)$$

where $\hat{\beta}_x$ and *x* are the vectors of coefficient estimates from the initial Cox proportional model, and $x\hat{\beta}_x$ and $(x\hat{\beta}_x)^2$ are the linear predictor and its square term. Under the assumption that $x\beta_x$ is the correct specification, coefficient estimates for the new Cox model will be $\hat{\beta}_1 = 1$ and $\hat{\beta}_2 = 0$. Link testing investigated the significance of the coefficient of the squared linear predictor, $(x\hat{\beta}_x)^2$, with the null hypothesis of $H_0 : \hat{\beta}_2 = 0$. Thus, the link-test statistic is the coefficient estimate of $\hat{\beta}_2$. This test suggests that if the null case is rejected, the model requires square terms of explanatory variables.

For all three models, link tests were carried out for the basic model that includes $\overline{TFP}$, firm size (*Y* or *L*), export, and *Age* as independent variables. The null of test statistics was rejected for all three models, as reported in Table 2. Thus, the square term of productivity ($\overline{TFP}^2$) was added as an explanatory variable to implement the link test again. Table 2 lists test results along with their statistical significance. In this second round of link testing, all three models accepted the null hypothesis, suggesting that the models did not require square terms of explanatory variables, with the exception of the square term of productivity.

Log-likelihood ratio testing was conducted to investigate the overall significance of explanatory variables in the model, under the null hypothesis that the explanatory variables would not have a significant relationship to the

3) Firm business experience is represented using two variables: "exports" denotes international business experience, and "age" denotes overall experience.

dataset. The likelihood-ratio test statistic can be expressed as $\lambda = -2[L(H_0) - L(H_1)]$, where $L(H_0)$ and $L(H_1)$ are the values of the log-likelihood function under the specifications of the null and alternative hypotheses, H_0 and H_1, respectively. If the null hypothesis were true, then λ would have an approximately *chi*-squared distribution with the degrees of freedom equal to the number of explanatory variables in the model. Log-likelihood testing rejected the null hypothesis in all three models, suggesting that as a whole, the explanatory variables had significant explanatory power.

In the total sample model, the coefficient estimate of the single term of productivity ($\overline{TFP}$) was significantly positive, but that of the square term of productivity ($\overline{TFP}^2$) was significantly negative. These findings indicate that the hazard of investment increases at a decreasing rate with increased productivity, suggesting that the timing of FDI is a quadratic function of a firm's productivity growth, implying that firms of medium-level productivity move first, followed by firms with higher or lower productivity. This result confirms the relationship between the two variables, as observed in Figure 1.

The U-shaped relationship between productivity and FDI waiting time is contrary to the general presumption that waiting time is a linearly negative function of a firm's level of productivity. The common presumption is that more productive firms are in a better position to compete in a foreign market and therefore execute FDI earlier than less productive firms. More productive firms also have more available resources for FDI than do less productive firms, so they would be expected to enter a foreign market earlier to exploit expected profits.

However, the empirical results suggest that firms with intermediate productivity levels tend to migrate first, whereas the most and least productive firms tend to stay behind. The probability of FDI success decreases as technological sophistication increases, which in turn is generally related to a firm's productivity. Specifically, quality control is a critical product-specific risk associated with foreign operations because potential investment failure may substantially erode expected FDI profits. This risk is especially threatening for firms that produce complicated products and use advanced technologies that require quality parts and components, skilled workers, and capable managers. Thus, other aspects being equal, firms with higher productivity face a higher

probability of FDI failure.

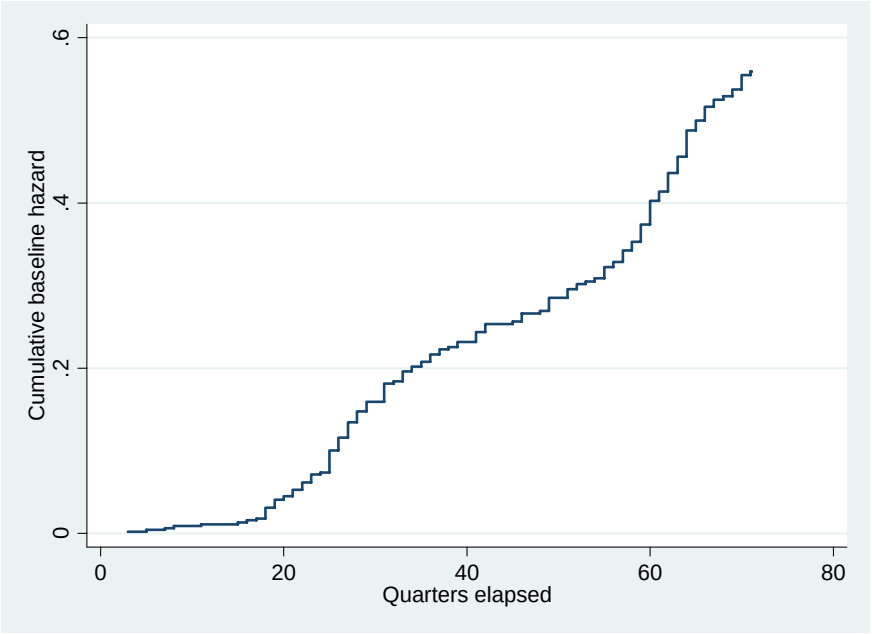
With regard to industry-wise estimation, coefficient estimates of productivity ($\overline{TFP}$) were positively significant in both industries, and those of the square term of productivity ($\overline{TFP}^2$) were negatively significant for the chemical industry. For this industry, empirical results confirmed the same relationship between productivity and FDI timing as in the total sample: firms with intermediate productivity levels migrated first, and the most and least productive firms tended to stay behind. However, the coefficient estimate of the square term of average productivity ($\overline{TFP}^2$) was insignificant in the fabrication industry. For this industry, estimation results revealed costs instead of benefits, as in the other models, that were associated with delayed FDI.

According to the original hypothesis of this study, it is beneficial for more productive firms to wait to undertake FDI because these firms generally require high-quality parts and components as well as quality labor to facilitate their production process. During the late 1980s, when FDI was first permitted in China, the Korean fabrication industry was in transition, moving up the industry's value chain from low-priced standardized products to high-quality products. Within this industry, firms that were competing in the world market by producing low-priced TVs, VCRs, and other home appliances were phased out, while firms producing relatively sophisticated computers, information technologies, and transportation products were expanding rapidly. To compete in the world market, firms specializing in low-priced generic products were forced to move their production bases to less-developed countries to utilize cheap foreign labor, while firms specializing in higher-end products stayed in Korea to utilize the country's research and development capacity and industrial network. In addition, the fabrication industry requires massive investments to build foreign factories, which tends to deter less productive and smaller firms from participating in FDI. As a result, more productive firms with sufficient resources migrated to China earlier than less productive firms. For firms producing massive quantities of low-technology products, FDI provided instant rewards that outweighed the benefits of waiting. However, most exporting firms competing in higher-end products stayed in Korea longer because FDI in China was riskier for them.[4)]

4) This reasoning is consistent with the coefficient estimates of industry output and exports: those of output were significantly positive, whereas those of exports were significantly negative.

With regard to other control variables, coefficient estimates of firm size, represented either by output (Y) or number of employees (L), were significantly positive in every model. In contrast, those of exports (Exp) were significant only in the fabrication industry model. Those of firm age (*Age*) were significantly negative only in the total sample model, and were insignificant in every other model.

<Figure 2> Estimated cumulative baseline hazard function for Korean manufacturing FDI in China



Although the Cox proportional hazards model cannot directly estimate the baseline hazard function [$h_0(t)$], estimates of this function can be derived based on estimates of β_x from the Cox model. Figure 2 depicts the baseline cumulative hazard function for Korean manufacturing FDI in China, conditional on coefficient estimates of the total sample. According to the function, Korean FDI in China increased very slowly for the first five years (20 quarters) after it was officially permitted in 1988. This finding suggests

that Korean firms hesitated to make investments in a new market for a period of time, due to the extreme risk from lack of information and data. However, after the initial period, FDI increased steeply until 1998, when the Korean economy was hit by the Asian financial crisis. Momentum slowed during this financial crisis from 1998-1999, but then FDI started to increase again, as Korean firms moved to China to seek a new growth engine.

The baseline cumulative function reveals that Korean FDI in China grew exponentially after the stagnant early years. This finding suggests that the probability of FDI success in China increased greatly in later years with China's rapid developments in economic infrastructure, increased labor productivity, and industrial agglomeration. These environmental factors in China affected all sample firms equally and were included as a baseline hazard.

Ⅳ. Conclusions

By focusing on the timing of each firm's first investment decision, this study analyzed how productivity affected decisions about FDI. The study was based on the hypothesis that firms with intermediate productivity tend to make their first investments earlier than firms with relatively high or relatively low productivity. Based on this prediction, the paper applied the Cox (1972) proportional hazards model to investigate how productivity affected firms' initial FDI in China, using Korean manufacturing data from 1988-2005.

Empirical results suggest that firms with intermediate levels of productivity are most likely to migrate first, whereas the most and least productive firms tend to stay behind. Firms with higher productivity levels may be associated with more advanced production technologies and may find it more difficult to ensure the quality of goods produced abroad, consequently delaying FDI implementation. In contrast, firms with lower productivity levels may lack the competitiveness and resources to move abroad.

Industry-wide modeling yielded similar results for the impact of productivity and direct investment timing within the chemical industry. However, in the fabrication industry, firms with higher productivity levels tended to carry out their first FDI earlier than did firms with lower productivity levels.

Future research will clarify whether these empirical findings are supported for firms from more developed countries. In addition, evidence based on datasets from other countries will provide more insights on this topic.

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