

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

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Abstract

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 revealed 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 demonstrated that the results held for the chemical industry.

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I. Introduction

When implementing foreign direct investment (FDI), firms must bear considerable initial sunk costs and heavy 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 up an appropriate supply network (Guiso and Parigi, 1999; Leahy and Whited, 1996).

Bell and Campa (1997) and Campa (1994) analyze how exchange rate uncertainty affects firms' decisions to delay entering a foreign market. Rajan and Marwah (1998) demonstrate that under conditions of policy-oriented uncertainty, firms are likely to postpone foreign investments until they are confident about the credibility of a host country's government. Rivoli and Salorio (1996) and Trigeorgis (1996) investigate how uncertainty affects FDI timing using an option theoretic framework and find that the value of waiting decreases with increased competitive pressure. Thus, firms tend to invest earlier if they have insufficient market power to withstand competition or if they face severe competition in a foreign market.

This study investigates 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 manufacture 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 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 undertake foreign investment earlier than firms with relatively high or relatively low productivity. Assuming this as a 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 tests 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 share 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 less productive firms are. Antràs and Helpman (2004) argue 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) develop a theoretical model in which the level of productivity is greater among FDI firms than among export-based and domestic firms. Kimura and Kiyota (2006) report, on the basis of Japanese firm level panel data, that more productive firms are more likely than less productive firms to use FDI. Similarly, Raff and Ryan (2008), drawing on data for Japanese firms' overseas investment from 1970-1994, find that among Japanese firms, increased productivity hastens a firm's first FDI and has a positive influence on follow-up investments. Tomiura (2007) demonstrates that among American firms, productivity levels are 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) demonstrate that firms with intermediate productivity levels are the first to migrate, and that the most productive and least productive firms tend to lag behind. Head and Ries (2003) argue that the least productive firms will undertake FDI if the host country is small and yields a comparative advantage 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) finds that productivity does not affect firms' FDI decision-making in the manufacturing sector, although it has a positive effect on FDI in the service sector.

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

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

Section II of this paper describes the methodology and data. Section III reports the empirical findings about the relationship between productivity and FDI timing. Section IV 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 :

$$h(t|x_i) = h_o(t)\exp(x_i\beta_x), \quad (1)$$

where x_i captures the effects of firm i 's firm-specific characteristics that influence investment likelihood; $h_o(t)$ is the "baseline" hazard function, which represents the hazard rate for each firm when all independent covariates are set to 0; and $h(t|x_i)$ is the proportion of $h_o(t)$ 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 uses data combined from two data sets: financial statement data and foreign direct investment data. The former were 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 were provided by Overseas Direct Investment Information, as compiled by Korea Eximbank.

The sample firms are all 422 Korean manufacturing firms listed on the stock exchange throughout the sampling period of 1988-2005, and their investments in China are traced using the FDI database. The sample includes 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 are 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 the sum of interest payments, rent, and depreciation costs. Total costs (C) are calculated as the sum of these factor costs ($C=C_L+C_K$), and a factor's share in the total costs (S_L, S_K) is applied 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 (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 ($=1, 2, \dots, T$) can be measured as follows.

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

where bars represent averages of the variables.

In estimation, the three-year-average productivity growth (\overline{TFP}) until FDI was officially permitted in China is used for 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 are 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 are classified into double-digit industries according to the International Standard Industry Classification (SIC). The chemical industry is represented by SIC 35 (chemical, petroleum, and coal products) and the metal fabrication industry by SIC 38 (fabricated metal products, machinery, and equipment).²⁾

Table 1 Variable Descriptions, Abbreviations, Means and Standard Deviations for the timing of FDI in China by Korean Manufacturing Firms

Variable	Description	Mean (SD)
Number of observations (N)	Number of the sample firms	422
Number of invested firms	Number of the firms that invested in China during the sampling period, 1988–2005	180
Number of quarters elapsed	Quarters elapsed for the Korean firms to implement their first FDIs in China Since the FDI was officially permitted	41.81 (18.02)
Total factor productivity (TFP)	Total factor productivity growth in the year FDI permitted for the first time, estimated by the chained-multilateral index number approach	1.8232 (4.9915)
Average growth rate of TFP (\overline{TFP})	Average growth rate of TFP for three years before investment permission	0.4620 (1.2779)
Real Output (Y)	Real value of output when FDI in China was allowed in 1988 for Korean firms	2,160,080 (6,212,091)
Number of employees (L)	Number of employee when FDI in China permitted	1,539.078 (3,303.435)

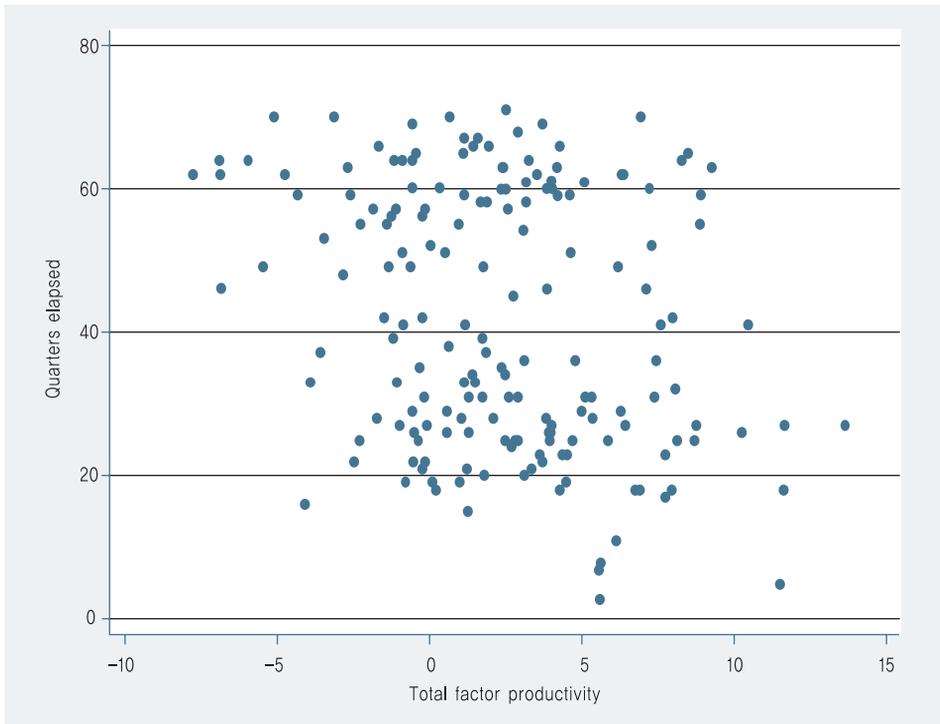
Note: All nominal units are set using 2000 constant prices and are in billion Korean Won.

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

The scatter plots in <Figure 1> show the number of quarters that elapsed (vertical axis) in the course of Korean firms' undertaking of their first FDI 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 approval of FDI. 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) for Korean manufacturing firms to invest in China since it was officially permitted and three-year-average TFP growth (horizontal axis)



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 metals 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 of Cox(1972) proportional hazards model on the timing of FDI in China since it was officially permitted for Korean manufacturing firms (Analysis time: number of quarters elapsed)

Explanatory Variables	Model				
	Total Sample	Textiles	Chemical	Basic-metal	Fabricated-metal
\overline{TFP}	0.4355* (0.1007)	0.5669 (0.5630)	0.6914*** (0.2758)	1.0157** (0.4643)	0.3562*** (0.1532)
\overline{TFP}^2	-0.1106* (0.0417)	-0.6750** (0.3112)	-0.2051*** (0.1185)	0.3457*** (0.1931)	0.0160 (0.0714)
L	0.00009* (0.00002)	0.0002 (0.0002)	0.0002** (0.00009)		
Y				-0.4775** (0.2424)	0.0419 (0.0267)
Exp	-0.0085 (0.0482)	-0.0493 (0.3731)	0.0184 (0.2432)	0.0842 (0.5871)	-0.1265*** (0.0715)
Age	-0.0106 (0.0070)	0.0054 (0.0290)	-0.0166 (0.0142)	-0.0029 (0.0404)	-0.0070 (0.0135)
LL	-1019.42	-54.77	-193.97	-29.98	-292.48
χ^2	49.14*	6.48	23.89*	13.55**	24.84*
Link-test statistic	0.0254 (0.0746)	0.4776 (0.3036)	0.0261 (0.1672)	0.0296 (0.1183)	-0.0662 (0.1213)
N	422(180)	34(18)	111(46)	44(10)	129(67)

Note: Standard errors in parentheses. (**, ***)denotes statistically significant at the 1(5, 10)% significance level. Bars on the variables represent three-year averages of the variables until the year when FDI to China was officially permitted.

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:

$$h(t|x_i) = h_o(t)\exp[\alpha_1(x_i \hat{\beta}_x) + \alpha_2(x_i \hat{\beta}_x)^2], \quad (3)$$

where $\hat{\beta}_x$ is the vector of coefficient estimates from the initial Cox proportional model, $x_i \hat{\beta}_x$ and $(x_i \hat{\beta}_x)^2$ are the linear predictor and its square term. Under the assumption that $x_i \hat{\beta}_x$ is the correct specification, coefficient estimates for the new Cox model will be $\hat{\alpha}_1=1$ and $\hat{\alpha}_2=0$. Link testing investigated the significance of the coefficient of the squared linear predictor, $(x_i \hat{\beta}_x)^2$, with the null hypothesis of $H_o: \hat{\alpha}_2=0$. Thus, the link-test statistic is the coefficient estimate of $\hat{\alpha}_2$. 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), exports, 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.

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

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 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 level, 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 less productive firms do, 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⁾

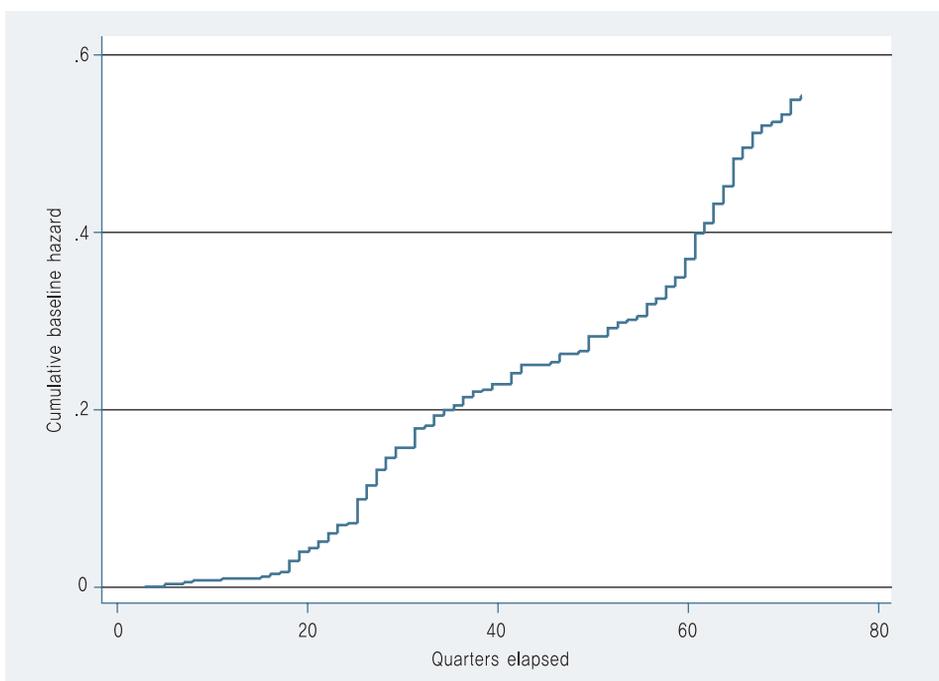
With regard to other control variables, coefficient estimates of firm size, represented either by output (Y) or number of employees (L), were significantly positive in every model. In contrast, those of exports (Exp) were significant only in the fabrication industry model. Those of firm age (Age) were

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.

significantly negative only in the total sample model, and were insignificant in every other model.

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 to 1999, but then FDI started to increase again, as Korean firms moved to China to seek a new growth engine.

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



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 to 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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