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Does Technology Transfer Help Small and Medium Companies? Empirical Evidence from Korea

Dae-Hwan Kim [1], Matarr O. Sambou [2,*] and Moo-Sup Jung [3]

[1] Department of Economics, Dong-A University, Busan 602-760, Korea; kimdh@dau.ac.kr
[2] Department of Economics, University of Calgary, Calgary, AB T2N 1N4, Canada
[3] Department of International Trade, Dong-A University, Busan 602-760, Korea; msjung@dau.ac.kr
* Correspondence: matarr.sambou@ucalgary.ca; Tel.: +1-403-890-5958

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Abstract: We challenge the view that technology transfer from big companies to small and medium (SM) size companies helps SM companies to prosper. With a large dataset of SM companies in Korea, we utilize the stochastic production frontier (SPF) model to examine the productivity of inputs and the generalized linear model (GLM) to compare business performance between two groups of SM companies: SM companies that receive technology transfer and those that do not receive technology transfer from big companies. The empirical results demonstrate that the transfer of technology from big companies to SM companies help SM companies to enjoy productivity of capital. Nonetheless, SM companies receiving technology transfer were found to underperform in terms of labor productivity and profit margin compared to their counterparts. We further investigate the reasons why SM companies receiving technology transfer from big companies underperform relative to their counterparts, and our findings shows that the former do not export much of their product and face more difficulties such as lower price for their products imposed by big companies than the latter. By identifying the negative rather than the conventionally assumed positive effect of technology transfer, this paper contributes to the literature on the relationship between technology transfer and SM companies' prosperity in the case of Korea. Our findings have important implications for how SM companies should strategize and rethink about the clauses embedded in the transfer of technology that they receive from big companies because technology transfer plays as a barrier to their prosperity.

Keywords: technology transfer; small and medium (SM) companies; productivity; globalization

1. Introduction

The creation or absorption of new technology has become a vital component for companies to improve or maintain their competitive position in the market place, especially in an environment where technology, competitive position, and customer demands can change frequently [1–3]. This is not surprising as the need for new technologies has grown in the past few years due to the trend of increased global competition and fast structural changes in the markets. Companies operating in sectors where competition takes place on the basis of price alone may rely on new technologies to improve efficiency in their production processes [4]. Technological innovation, therefore, plays an important role in the growth of firms [3,5,6] and helps determining the success and long-run sustainable growth of firms [7].

South Korea (henceforth Korea) has shown miraculous economic growth with rapid changes of its technology strategy such as Technology Transfer and Technology Commercialization, over the past 30 years. One of the most important driving forces of this growth is investment in large-scale facilities, development of infrastructure, and aggressive acquisition of the most advanced technology

in the global market. Activities in technology transfer and commercialization became robust in the country when parliament enacted the Technology Transfer Promotion Act in 2000. Through government support programs, the Act is passed to encourage the transfer and commercialization of Research and Development (R&D), with the intention of bolstering growth, particularly at the service sector [5]. In other sectors, where the market evolves incessantly as new products with new functions or designs appear on a regular basis, companies are forced to innovate by acquiring or developing new technologies. Technological innovation is therefore a crucial element of the competitive strategy of any company, big or small, high-tech or low-tech [8].

The on-going integration of domestic and international markets through continuing deregulation and liberalization of markets has enhanced competitive pressure for all firms. Thus, increased the technological needs of small companies worldwide while also improving their access to new technologies and capital goods. Small and medium (SM) companies have to decide whether to develop technology in-house or to obtain it from others. While investing in technology creation may be expensive and risky, as there are many uncertainties linked to the innovation process, SM companies have the advantage to gain access to cutting-edge innovations by depending on big companies through technology transfer. However, there are some constraints faced by SM companies which benefit from the transfer of technology from big companies to bolster their production processes, particularly in Korea. This has made the whole technology transfer phenomenon more complicated and disadvantageous to many SM companies benefiting from it.

According to the database system operated by the Small and Medium Business Administration (SMBA), which is a Korean government organization, the economic and social roles of SM companies are essential for national economic stability. Since around 87.9% of workers in the labor market are working in SM companies and the proportion of SM companies among all is 99.9% in 2015. Due to this increasing trend of labor market participants in this sector, there is increasing demand and interest in innovation. This shows that innovation capacity is determining competitive advantage and the continuing existence of companies in the market [9,10]. However, SM companies face various limits to rely entirely on their own R&Ds and technology for sound and stable growth. Therefore, it is important for companies of different sizes to share knowledge among themselves in a more harmonious way to enhance stable and sustainable growth. Though companies benefit from knowledge spillovers [11], there are some challenges involved when companies of various sizes share knowledge among themselves. Depending on the nature of the technology and capacity of the recipient, the process of technology transfer may be simple and straightforward but usually is fairly complex.

Thus, the issue we want to tackle in this article is to investigate what impact the transfer of technology from big companies to SM companies has on the overall prosperity of SM companies in the case of Korea. We employed stochastic production frontier (SPF) model first introduced by Aigner et al. [12] and Meeusen and Broeck [13] to trace out the effect technology transfer has on productivity and inefficiency, particularly among SM companies receiving technology transfer from big companies. Then, we performed additional analyses to find out the reasons of different productivity or inefficiency between SM companies receiving technology transfer and those which are not receiving it. To find out the reasons, we employed the generalized linear model (GLM) to compare the performance level between the two groups of SM companies. Using a sample of 32,084 SM companies in Korea, we found out that SM companies receiving technology transfer from big companies have higher productivity than their counterparts based on their level of capital. This is because SM companies with technology transfer have larger capital stock than those without it since technology is part of the capital that firms used to produce their products. However, the results from the GLM shows that SM companies without technology transfer have higher labor productivity and profit margin than those with it. Finally, our findings show the reasons why SM companies with technology transfer perform poorly because they are less likely to export and more likely to face various difficulties imposed by big companies who transfer them with the technologies.

The remainder of the paper is organized into three additional sections. The second section presents the data used followed by the empirical analysis of our investigation on the effect technology transfer has on SM companies. The section after that presents the empirical results of our findings using the SPF and GLM models. The paper ends with some concluding remarks.

2. Data and Empirical Analysis

2.1. Data

For the empirical analysis, we use pooled data from most current Five-Year Survey for Small and Medium Businesses (SMBs) from 2009 to 2013 [14]. The SMB surveys about 7000 or 8000 SM businesses every year based on the Minor Enterprises Act and Statistics Act in Korea. From 2009 to 2013, SMBs of 39,000 were surveyed. We limit our samples into purely SM companies that deliver their products to big companies because the main purpose of this study is to compare two different groups of SM companies (SM companies with technology transfer and those without it). In this study, 32,084 SM companies were employed for the empirical analysis after omitting observations with missing information.

We first compare the productivity between the two groups. We hypothesized that SM companies with technology transfer enjoy higher productivity of capital than their counterparts since it would not be necessary for them to invest a lot in developing technologies. Following Zellner and Revanar [15] and Greene [16] for the comparison of capital and labor productivity, added values, which are defined as quantity multiplied by the gap between price of the product and cost of producing the product except for wages, are utilized. Using observations of the transportation-equipment manufacturing industry, Zellner and Revanar [15] analyzed a Cobb–Douglas production function using log-transformed values added as the dependent variable and log-transformed values of labor and capital.

Secondly, we compare the performance of both companies using two different indicators as proxies for business performance: sales margin, which is defined as net profit divided by amount of sales and amount of exports. The reason why we did not use the amount of net profit is because the amount of net profit would simply reflect the amount of sales or firm size. It would be reasonable to think that SM companies receiving technology transfer from big companies outperform their counterparts. It is also possible, however, that SM companies which do not receive technology transfer outperform SM companies receiving it, if they face irrational coercions imposed by big companies that transfer them with the technologies. That is, technology transfer could be an obstacle to SM companies receiving it to perform. Using descriptive statistics, we compare whether they experienced irrational coercions or difficulties imposed by big companies. We hypothesize that big companies which offer SM companies with the technologies would require compensation in requital for the transfer.

Table 1 contains the list of explanatory variables and their definitions. The main independent variable is the binary variable of Technology Transfer, which is equal to 1 if an SM company received technology transfer from big companies, and 0, otherwise. Other explanatory variables, which can affect the dependent variable, are controlled and they are: size of the company which is defined as the number of workers, amount of capital and export, years of business period, a binary variable which is equal to 1 if the company is managed by a chief executive officer (CEO) and 0 otherwise, location of factory, types of business, location of company, and year dummies which can reflect the unobserved factors in the specific year [16].

Table 1. Variable names and definition.

Variables	Definition
Technology Transfer	=1 if received technology transfer from big companies, 0 otherwise
Log (Added Value)	Log (Added values which are sales amount minus production costs except for wages)
Log (Profit Margin)	Log (profits divided by amount of sales)
Log (Export)	Log (amount of export)
Log (Workers)	Log (number of workers)
Log (Capital)	Log(capital)
Log (Business Age)	Log (years of business period)
CEO	=1 if operated by CEO and 0 if operated by owner
Location 1	=1 if factory is located in domestic, 0 otherwise
Location 2	=1 if factory is located in overseas, 0 otherwise
Location 3	=1 if factory is located in domestic and in overseas, 0 otherwise
Location 4	=1 if does not have a factory, 0 otherwise
Type 1	=1 if business type is technological innovation, 0 otherwise
Type 2	=1 if business type is venture, 0 otherwise
Type 3	=1 if business type is management innovation, 0 otherwise
Type 4	=1 if business type is general, 0 otherwise
Year 2009	=1 if samples are from 2009, 0 otherwise
Year 2010	=1 if samples are from 2010, 0 otherwise
Year 2011	=1 if samples are from 2011, 0 otherwise
Year 2012	=1 if samples are from 2012, 0 otherwise
Year 2013	=1 if samples are from 2013, 0 otherwise
Region 1	=1 if business is located in region 1, 0 otherwise
Region 2	=1 if business is located in region 2, 0 otherwise
Region 3	=1 if business is located in region 3, 0 otherwise
Region 4	=1 if business is located in region 4, 0 otherwise
Region 5	=1 if business is located in region 5, 0 otherwise
Region 6	=1 if business is located in region 6, 0 otherwise
Region 7	=1 if business is located in region 7, 0 otherwise
Region 8	=1 if business is located in region 8, 0 otherwise
Region 9	=1 if business is located in region 9, 0 otherwise
Region 10	=1 if business is located in region 10, 0 otherwise
Region 11	=1 if business is located in region 11, 0 otherwise
Region 12	=1 if business is located in region 12, 0 otherwise
Region 13	=1 if business is located in region 13, 0 otherwise
Region 14	=1 if business is located in region 14, 0 otherwise
Region 15	=1 if business is located in region 15, 0 otherwise
Region 16	=1 if business is located in region 16, 0 otherwise

Notes: Reference groups for dummy variables are Location 1, Type 1, Year 2009, and Region 1.

Descriptive Statistics

We distinguish the distributive statistics for all samples of SM companies in our analysis, that is, samples with technology transfer and samples without technology transfer, and this is highlighted in Table 2. On average, 9.6% of SM companies have technology transfer. The proportion of workers in SM companies with technology transfer is higher than those without it. Hence, the number of workers in the labor market working in SM companies receiving technology transfer from big companies is, on average, 13.291 higher than SM companies which are not receiving it.

Since technology is one of the components of capital used by companies in their production processes [17], SM companies which receive technology transfer have some comparative advantage over those which are not benefiting from it in terms of the amount of capital used in their production processes. Thus, SM companies with technology transfer are found to have, on average, a capital worth of 369,101 won higher than SM companies without it.

However, the proportion of the profit margin and export is greater among SM companies without technology transfer than those with technology transfer. The average business age is 13.412 for all samples, and it is obvious that the average business age among samples without technology transfer is much higher, which is consistent with previous literature [5]. In addition, the proportion of value

added on the products is much higher among SM companies without technology transfer and the difference, on average, amounted to 56,682 won.

The average number of SM companies operated by CEOs are found to be higher among SM companies without technology transfer. This may be true because SM companies which are not benefiting from the transfer of technology from big companies would need the service of CEOs to help run the affairs of the business, particularly in terms of proper management of company resources. In order words, SM companies without technology transfer needs to invest in R&D, and thus the job of a CEO is necessary in allocating their limited resources more effectively and efficiently in other for them to be able to use cutting-edge technology in their production processes. Although, to the best of our knowledge, there are few, if any, related studies that investigate the transfer of technology between companies of different sizes, prior studies have confirmed that technology is positively correlated with the output level of companies [9,10].

Table 2. Descriptive statistics.

Variables	Whole Samples		Samples without Technology Transfer		Samples with Technology Transfer	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Log (Added Value)	13.506	1.381	13.490	1.391 ***	13.645	1.274
Log (Profit Margin)	−3.332	0.982	−3.323	0.977 ***	−3.409	1.022
Log (Export)	3.249	6.081	3.248	6.075	3.256	6.140
Log (Workers)	3.180	0.997	3.148	0.992 ***	3.487	0.994
Log (Capital)	14.035	1.559	14.022	1.560 ***	14.153	1.544
Log (Business Age)	2.376	0.693	2.380	0.692 ***	2.331	0.703
CEO	0.803	0.398	0.804	0.397 **	0.788	0.409
Location 1	0.911	0.285	0.912	0.284	0.901	0.298
Location 2	0.007	0.081	0.007	0.082	0.007	0.080
Location 3	0.012	0.108	0.011	0.106 ***	0.018	0.131
Location 4	0.071	0.257	0.071	0.256	0.075	0.263
Type 1	0.283	0.451	0.280	0.449 ***	0.317	0.465
Type 2	0.035	0.184	0.035	0.184	0.035	0.183
Type 3	0.006	0.075	0.005	0.072 ***	0.009	0.093
Type 4	0.676	0.468	0.680	0.466 ***	0.639	0.480
Year 2009	0.217	0.412	0.218	0.413	0.211	0.408
Year 2010	0.224	0.417	0.226	0.419	0.198	0.399
Year 2011	0.155	0.362	0.157	0.364 ***	0.140	0.347
Year 2012	0.220	0.414	0.222	0.416	0.199	0.399
Year 2013	0.184	0.388	0.177	0.382 ***	0.252	0.434
Region 1	0.092	0.288	0.093	0.291 ***	0.076	0.264
Region 2	0.083	0.275	0.084	0.277 *	0.070	0.256
Region 3	0.062	0.240	0.060	0.238 ***	0.074	0.262
Region 4	0.075	0.263	0.075	0.264	0.073	0.260
Region 5	0.032	0.176	0.031	0.173 ***	0.046	0.209
Region 6	0.034	0.181	0.035	0.183 *	0.026	0.160
Region 7	0.036	0.187	0.032	0.177 ***	0.074	0.262
Region 8	0.179	0.383	0.181	0.385 ***	0.156	0.363
Region 9	0.032	0.175	0.033	0.178 ***	0.018	0.134
Region 10	0.055	0.228	0.056	0.230 **	0.045	0.208
Region 11	0.062	0.242	0.062	0.240 **	0.068	0.252
Region 12	0.046	0.209	0.047	0.212 **	0.034	0.182
Region 13	0.040	0.196	0.040	0.197	0.038	0.192
Region 14	0.075	0.264	0.075	0.263	0.077	0.267
Region 15	0.088	0.284	0.085	0.279 ***	0.121	0.326
Region 16	0.010	0.099	0.011	0.102 ***	0.003	0.057
Number of Samples	32,084		29,013		3071	

Notes: (1) reference groups for dummy variables are Location 1, Type 1, Year 2009, and Region 1; (2) *, **, and *** indicate statistically significant at 10%, 5%, and 1% level, respectively, between two sample means of SM companies with and without technology transfer; and (3) unit for added values, profit margins, export are 1000 Korean won which is similar with 1 US dollar (actual currency exchange rate is $1 = 1150 won).

2.2. Stochastic Production Frontier

To investigate the productivity disparity between the two groups of SM companies, we employ the SPF model. The SPF model has been heavily used to fit stochastic production or cost function after it was introduced by Aigner et al. [12] and Meeusen and Broeck [13].

In the beginning stage of developing stochastic production function, theoretical and empirical approach did not explicitly formulate a model for inefficiency effects in terms of appropriate explanatory variables. Thus, we adopt an empirical model following Battese and Coelli [18]. We first estimate the stochastic frontier production function and predict the inefficiency, and then estimate the effects of environmental variables on the estimated inefficiency.

Following the notation by Meeusen and Broeck [13], a company i produce Y_i with the stochastic production function

$$Y_i = \exp\left(X_i\beta + v_i - u_i\right), \tag{1}$$

where X is a vector of inputs, β is a vector of estimated parameter, and v is assumed to be i.i.d (independent and identically distributed) $N\left(0,\ \sigma_v^2\right)$ random error. Finally, u is a non-negative random variable, which is associated with inefficiency. That is, in the second stage of the empirical analysis, u is a function of characteristics of a firm, z:

$$u_i = z_i\delta + W_i\ , \tag{2}$$

where W is defined by the truncation of the normal distribution. If σ_u^2 is equal to 0, SPF reduces to ordinary least squares (OLS) [19].

Following Zellner and Revanar [15] and Greene [16], we use a log-transformed value added as Y_i and a log-transformed number of workers and log-transformed amount of capital as input variables in the first stage of estimation. Various characteristics of a firm including a dummy variable which is equal to 1 if a firm receives technology transfer from a big company, and 0 otherwise, are employed as z in the second stage of estimation.

2.3. Generalized Linear Model

We employ the GLM model to compare the performance of SM companies. After the theory of GLM was developed by Nelder and Wedderburn [20], GLM models have been widely used in various applications [21,22]. The model has a single response (dependent) variable, in which it explains and is hypothesized to follow a number of single parameter exponential families of probability distributions. The backbone of exponential families is usually written as:

$$f_y\left(y;\theta,\varphi\right) = \exp\left\{\frac{y\theta - b\left(\theta\right)}{\alpha\left(\varphi\right)} + c\left(y,\varphi\right)\right\}, \tag{3}$$

where y represents the response variable, $f\left(\cdot\right)$ is the generic form of the density function y, θ is the canonical parameter and φ is the scale required to produce standard errors following a distribution in the exponential families, $b\left(\theta\right)$ is the cumulant which describes moments, $c\left(y,\varphi\right)$ is a normalization function, and $\alpha\left(\varphi\right)$ is the scale parameter.

The purpose of using GLM models is to investigate the effect of technology transfer on business performance such as amount of profit margin and export. Since profit margin and export are continuous response variables, we used Gaussian, gamma, and inverse Gaussian families. As criteria for model selection among the various GLM models, Akaike Information Criterion (AIC) [23] and Bayesian Information Criterion (BIC) [24] are utilized. Both criteria propose that a model with the lowest value is preferred, and thus BIC imposes a harsher penalty as log values of sample size are in general greater than 2 [21]. According to both AIC and BIC, the log-normal model is preferred to other GLM models for technology transfer effects on business performance. The log-likelihood function for log-normal

model can be written after simply substituting $\exp(X\beta)$ for each instance of $X\beta$ in the log-likelihood function of Gaussian model that is well known:

$$L\left(\mu; y, \sigma^2\right) = \sum_{i=1}^{n} \left\{ \frac{y_i \exp\left(X_i\beta\right) - \left\{\exp\left(X_i\beta\right)\right\}^2/2}{\sigma^2} - \frac{y_i^2}{2\sigma^2} - \frac{1}{2}\ln\left(2\pi\sigma^2\right) \right\}, \quad (4)$$

where X represents the vector of explanatory variables and β is the vector of estimated coefficients.

3. Empirical Results

3.1. Productivity

Table 3 presents the results of the productivity analysis using SPF for all samples. We apply the same approach separately for SM companies with and without technology transfer from big companies, respectively, to compare the productivity of labor and capital between the two groups. However, estimating productivity by separating the samples of SM companies is not applicable to examine the effect of technology transfer on inefficiency directly. Thus, in the second stage, we estimate the effect of various characteristics including technology transfer on inefficiency, using all samples.

The empirical results presented in Table 3 are obtained from a truncated SPF; however, the results are a little different from a half-normal and an exponential SPF. Furthermore, as shown in Table 3, the test for the null hypothesis that $H_0 : \sigma_u^2 = 0$ is rejected at the 1% level of significance for both SM companies. Thus, the test result suggests that SPF is preferred to OLS.

According to the estimated coefficients for all SM companies, as the number of workers and amount of capital increase by 1%, productivity (measured using added values) increases by 0.555% and 0.455%, respectively. For SM companies that do not receive technology transfer from big companies, as the number of workers and amount of capital increase by 1%, productivity increases by 0.582% and 0.395%, respectively. On the other hand, 1% increase in the number of workers and amount of capital increased productivity by 0.445% and 0.504%, respectively, for SM companies with technology transfer. The estimated results confirmed that SM companies which receive technology transfer outperform their counterparts in terms of capital productivity. This is because SM companies receiving technology transfer from big companies have a comparative advantage in terms of new technologies and the amount of capital use in their production processes. Therefore, they have more room to increase the value of their products relative to those produced by their counterparts. Interestingly, however, SM companies with technology transfer underperform those without technology transfer based on the number of labor productivity. This is breathtaking, despite the fact that SM companies which are receiving technology transfer from big companies have more workers relative to those which are not receiving technology transfer.

From Table 3, overall, the size of inefficiency is found to be greater for SM companies with technology transfer than those without it. That is, an estimated inefficiency size of 0.434 for SM companies without technology transfer and 0.452 for those with it, respectively, shows that SM companies without technology transfer are less inefficient than their counterparts.

From the second stage of the analysis, estimating the direct effect of technology transfer on inefficiency instead of comparing the sizes of inefficiency between the two groups in the first stage, confirmed that technology transfer increases inefficiency. According to the estimated coefficient, receiving technology transfer from big companies increases inefficiency by 3.3%. It is also convincing to say that, as the amount of export increases, inefficiency decreases and the estimated coefficient is statistically significant at the 1% level of confidentiality. Though the size of the estimated coefficient is found to be small, the expected sign and the magnitude of the estimated coefficient have some interesting statistical analysis and are in line with a prior result. That is, when export increases by 1%, inefficiency decreases by 0.002%. The length of time companies has been in business is found to have a more robust significant effect on the inefficiency level and thus increase the inefficiency level of SM companies. The estimated coefficient on business age is 0.024, and it is statistically different from

zero. The result shows that a 1% increase in the length of time an SM company has been in business, its inefficiency level increases by 2.4%, holding fixed all other variables. It is shown that SM companies that are operated by CEOs are more efficient than SM companies that are operated by their owners. Nevertheless, the estimated coefficients on year dummy variables suggest that SM companies become more efficient over time.

Table 3. Productivity and inefficiency analysis using Stochastic Production Frontier (SPF).

First Stage: Stochastic Frontier Analysis						
Variables	**All Samples**		**Samples without TT**		**Samples with TT**	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Log (Workers)	0.555	0.006	0.582	0.006	0.395	0.015
Log (Capital)	0.455	0.004	0.445	0.004	0.504	0.009
_cons	5.81	0.039	5.881	0.042	5.578	0.108
Inefficiency	0.436		0.434		0.452	
Second Stage: Inefficiency Analysis with All Samples						
Variables	**Coef.**		**Std. Err.**			
Technology Transfer	0.033		0.007 ***			
Log (Export)	−0.002		0.000 ***			
Log (Business Age)	0.024		0.003 ***			
CEO	−0.067		0.005 ***			
Location 2	−0.052		0.026 ***			
Location 3	−0.012		0.019			
Location 4	0.039		0.008 ***			
Type 2	0.021		0.012 *			
Type 3	−0.027		0.027			
Type 4	0.051		0.005 ***			
Year 2010	0.01		0.006			
Year 2011	−0.029		0.007 ***			
Year 2012	−0.011		0.006 *			
Year 2013	−0.044		0.007 ***			
Region 2	0.068		0.011 ***			
Region 3	0.123		0.011 ***			
Region 4	0.085		0.011 ***			
Region 5	0.083		0.014 ***			
Region 6	0.108		0.013 ***			
Region 7	0.075		0.013 ***			
Region 8	0.071		0.009 ***			
Region 9	0.16		0.014 ***			
Region 10	0.102		0.012 ***			
Region 11	0.101		0.011 ***			
Region 12	0.127		0.012 ***			
Region 13	0.115		0.013 ***			
Region 14	0.108		0.011 ***			
Region 15	0.1		0.010 ***			
Region 16	0.135		0.022 ***			
_cons	0.335		0.015 ***			

Notes: (1) * and *** indicate statistically significant at 10%, 5%, and 1% level, respectively; (2) Prob > Chi2 = 0.000 for all estimations.

3.2. Effect of Technology Transfer on Performance and Globalization

The long-run survival of firms and companies and their competitiveness in the global market depends on their level of innovation and adaptability to new technologies [3,10]. However, Yi et al. [25] and Deng et al. [26] challenge the traditional view that innovations always help exporters prosper in competitive international markets by developing and testing the premise that the relationship between innovation and export performance is contingent on some important firm- and location-specific

institutional idiosyncrasies. With a large dataset of Chinese firms, their empirical results demonstrate that innovation could be detrimental to exporter survival. Nonetheless, they also observe a positive relationship between innovation and survival in highly profitable exporters.

Using a log-normal model of GLM models, we investigate the effect of technology transfer on business performance such as profit margin and amount of exports, and the empirical results are presented in Table 4. According to the estimated coefficients, technology transfer reduces profit margin by 7.3%. This finding is consistent with previous literature on the relationship between innovations and exports [26]. However, it is confirmed that the greater the amount of export, the greater the profit margin. According to the estimated coefficient of export, holding everything else fixed, 1% increase in export increases profit margin by 0.006% and the estimated effect is statistically significant at the 1% level of significance.

Table 4. Business performance analysis using Generalize Linear Model (GLM).

Variables	Log(Profit Margin)		Log(Export)	
	Coef.	Std. Err.	Coef.	Std. Err.
Technology Transfer	−0.073	0.020 ***	−0.453	0.109 ***
Log (Export)	0.006	0.001 ***	-	-
Log (Worker)	−0.067	0.007 ***	0.746	0.057 ***
Log (Business Age)	−0.034	0.009 ***	0.577	0.050 ***
CEO	−0.380	0.015 ***	0.481	0.089 ***
Location 2	−0.193	0.073 ***	3.234	0.401 ***
Location 3	0.041	0.054	5.250	0.295 ***
Location 4	0.020	0.024	0.112	0.132
Type 2	−0.039	0.034	−0.255	0.189
Type 3	−0.216	0.077 ***	−0.595	0.432
Type 4	−0.102	0.014 ***	−1.495	0.075 ***
Year 2010	0.147	0.018 ***	−0.989	0.102 ***
Year 2011	0.070	0.019 ***	0.661	0.109 ***
Year 2012	0.036	0.018 **	0.039	0.100
Year 2013	0.022	0.018	0.503	0.103 ***
Region 2	0.184	0.030 ***	−1.164	0.168 ***
Region 3	0.087	0.032 ***	−1.479	0.177 ***
Region 4	0.066	0.030 **	−0.334	0.169 **
Region 5	0.076	0.038 **	−1.614	0.215 ***
Region 6	0.264	0.038 ***	−0.845	0.211 ***
Region 7	0.198	0.037 ***	−2.437	0.206 ***
Region 8	0.081	0.026 ***	−0.256	0.144 *
Region 9	0.157	0.039 ***	−0.963	0.216 ***
Region 10	0.080	0.033 **	−0.999	0.182 ***
Region 11	0.027	0.032	−1.306	0.177 ***
Region 12	0.060	0.034 *	−1.601	0.192 ***
Region 13	0.072	0.036 **	−1.749	0.200 ***
Region 14	0.039	0.030	−1.466	0.169 ***
Region 15	0.055	0.029 *	−1.300	0.163 ***
Region 16	0.179	0.061 ***	−2.035	0.341 ***
_cons	−2.821	0.039 ***	−8.605	0.509 ***

Notes: (1) *, **, and *** indicate statistically significant at 10%, 5%, and 1% level, respectively; (2) Prob > F = 0.000 for both profit margin and export estimations.

It is not reasonable to accept the empirical results that technology transfer reduces productivity and profit margins. Thus, we investigate the reasons as to why productivity and profit margin of SM companies which are receiving technology transfer from big companies are worse off compared to their counterparts. According to the empirical results, the amount of export is found to be an important determinant both for inefficiency and profit margin, and we hypothesize that technology transfer plays as a barrier for exporting products of firms receiving it.

The results of testing the hypothesis are presented in the left column of Table 4. It is found that technology transfer reduces the amount of exports a lot. According to the estimated coefficients, technology transfer reduces the amount of export by 45.3%. Considering this huge negative effect of technology transfer on exports, it is convincing to say that technology transfer reduces productivity and profit margin through export performance. Empirical results are barely different even after replacing the dependent variable of log-transformed amount of exports with log-transformed amount of exports divided by total amount of sales.

Thus, it is reasonable to think that technology transfer itself does not reduce exports. The possible reasons would be various. First, big companies which transferred their technology to SM companies would require SM companies to sell their products only or mainly to them. Second, SM companies that can sell their products to companies that transfer technology to them would be less likely to find clients overseas.

The number of workers that the company has, the length of time it has been in business, and if it is operated by CEOs were found to have an adverse effect on the profit margin of SM companies. This is not surprising because although companies' CEOs and workers contribute immensely towards the success and profitability of companies [27,28], they are also a cost burden to companies that hire them. Nonetheless, these variables were found to have a robust and statistically significant effect on the export level of SM companies.

3.3. Difficulties Faced by SM Companies Receiving Technology Transfer

Although it is reasonable to think that technology transfer plays a positive role in the performance of business, our empirical investigations present the opposite consequences of technology transfer. To find out the more detailed reasons for the consequences faced by SM companies receiving technology transfer from big companies, we compare the types and levels of difficulties experienced by SM companies with and without technology transfer.

The results of our findings are shown in Table 5, and they present surprisingly unacceptably unfair relationships between SM companies that receive technology transfer and big companies that transfer their technologies to them. Looking at the results presented in Table 5, which are based on a survey conducted by SMBA. SMBA asks SM companies to choose one of the difficulties listed in Table 5 that they experienced when it comes to doing business with big companies.

Table 5. Difficulties imposed by big companies.

Difficulties Imposed by Big Companies (Shackles from Big Companies)	Samples without Technology Transfer		Samples with Technology Transfer	
	Number of Firms	Proportion	Number of Firms	Proportion
Requires too much high quality	897	0.031	1005	0.327
Does not reflect increased costs of raw materials	1861	0.064	823	0.268
Reduce prices	817	0.028	441	0.144
Does not pay for products received on time	242	0.008	82	0.027
Irregular order	182	0.006	162	0.053
Rush delivery and reduce delivery period	93	0.003	99	0.032
Change subcontractor unilaterally	19	0.001	8	0.003
Requires patent technology and information	4	0.000	1	0.000
Conflict with calculating production costs	42	0.001	47	0.015
Does not pay for bill discount	18	0.001	2	0.001
Other difficulties	0	0.000	84	0.027
No answer	0	0.000	2	0.001
No difficulties	24,838	0.856	315	0.103
Number of Samples	29,013		3071	

From the results presented above, based on high quality requirements, the number of SM companies without technology transfer that are required to provide high quality products in the market are less than that of their counterparts with a lower proportion. Since 29,013 of SM companies without technology transfer and 3071 of SM companies with it took part in the survey conducted by

SMBA, the proportion of companies or firms facing such a difficulty imposed by big companies is higher for SM companies with technology transfer than those without it. However, in terms of reflecting the increasing cost of raw materials, reducing prices, paying for products on time and irregularities, SM companies without technology transfer have a higher number of firms that respond to such questions than their counterparts and again with a lower proportion. This shows that SM companies without technology transfer are more transparent and bold enough to present the kind of difficulties imposed by big companies that they are facing and what is happening in their businesses than their counterparts.

Finally, looking at the overall satisfaction level of SM companies with regards to the difficulties they encounter, SM companies that are receiving the transfer of technology from big companies were found to be less satisfied than their counterparts. Comparing the two separate SM companies based on the difficulties each face, SM companies which are not receiving technology transfer from big companies were found to answer more in the affirmative that they are facing less difficulties than their counterparts. This shows that SM companies which are receiving technology transfer from big companies are left with no choices but to play by the rules of big companies for them to continue benefiting from the innovations provided by the big companies.

4. Conclusions

Combining firms or companies which are either receiving or not receiving technology transfer from big companies, we employ a large dataset of SM companies in Korea to investigate the relationship between technology transfer and firm's performance by asking: does technology transfer from big companies to SM companies help SM companies? The results suggest that technology transfer, though good for SM companies that do not have to worry about investing in R&D to bolster production and growth, reduce their labor productivity, profit margin and export share. This shows that, technology transfer has a negative rather than a positive effect on SM companies' overall performance. This is because SM companies which are receiving the transfer of technology from big companies are faced with some constraints to compete both in the local and international market for their products.

However, we also find that technology transfer does not have a uniform negative effect across all firms which are receiving the transfer of technology from big companies in all specifications. Instead, it shows some positive and statistically significant effects on capital, which, in turn, increase the productivity of SM companies that are benefiting from technology transfer more than their counterparts.

Our findings have several implications for future research on the relationship between technology transfer and the prosperity of SM companies. First, our study highlights the academic value of distinguishing the three different types of outcomes of technology transfer on SM companies, that is, productivity, export, and profit margin. Merely focusing on the productivity of SM companies receiving technology transfer from big companies, prior research has neglected the importance of such transfer on export and profit margins of SM companies that are benefiting from the transfer.

We demonstrate that while technology transfer to SM companies may enhance productivity through capital, this does not necessarily mean that it is a good thing for SM companies to continue receiving technology transfer from big companies. While research on innovation, particularly technology transfer, remains important for theoretical and practical reasons, future research should extend to examination of the survival of SM companies that are receiving technology transfer. Second, our findings challenge the view that technology transfer only has a positive value for SM companies receiving it. We show that technology transfer can be a liability for SM companies that want to compete in the global market.

Though we are not concluding that technology transfer may drive SM companies that have export ambitions out of the global market, the limiting opportunities given to them will hinder their aspirations for competition in the international market. This is particularly true for SM companies in Korea, as their ability of both developing innovative products to suit the needs of their customers

(locally and internationally) and of achieving profitability from exports depends on the big companies that are transferring their technologies to them. Thus, this can drive some of the SM companies out of business because of the limited avenue given to them to exercise their marketing powers. Therefore, this study adds to the existing literature, if any, on the value of technology transfer on SM companies, particularly those in emerging markets.

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