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Participation in the Kaesong Industrial Complex and its impact on productivity: South Korean textile firms' experiences

Sungtaek Cho[a], Do Won Kwak[b], Hongshik Lee[a,*]

[a] Department of Economics, Korea University, Republic of Korea
[b] Graduate School of International Studies, Korea University, Republic of Korea

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ABSTRACT

This paper examines the effects of participating in the KIC on firms' productivity using firm-level data from 1998 to 2012, focusing on the textile sector. To do this, we implemented PSM estimations employing the radius matching method with 0.01 caliper and 10nearest-neighbor matchings with replacement. We found 100 matched firms in control groups(domestic firms) that corresponded to each of the 10 treated firms.

For analysis, we used a difference-in-differences (DID) framework and extended the basic DID framework to the event study framework of Gathmann et al. (2018). The results reported that the treated firms experienced the increased sales but the improvement in sales had not lead to improvements in productivity. These results can be found in the DID event study as well as the DID analysis. That is, improvement in productivity through FDI cannot be found in the empirical results.

1. Introduction

The Kaesong Industrial Complex (KIC) was symbolic, economic cooperation between South and North Korea from 2004 to 2016. Beginning in 2004, the KIC's operation had been relatively stable in spite of several crises resulting from deteriorating inter-Korean relations. KIC also had grown dramatically regarding size until it was shut down in the wake of the fourth nuclear test by North Korea in January 2016. At present, whether the KIC will resume operations is unclear, but as inter-Korean relations appear to be thawing, the prospects for the discussion of inter-Korean economic cooperation and resumption of the KIC are high. The number of firms operating in the KIC had increased to 123 by 2016, with cumulative total sales of more than $ 2.2 billion. And, the industrial complex employed approximately 53,000 North Korean workers hired by South Korean firms, as well as more than 700 workers from South Korea.

Despite the uncertainty concerning reopening the complex, a first evaluation of the KIC can provide insights for firms contemplating participating in South-North economic cooperation in the future. Additionally, analyzing the performance of firms in the KIC is of great value as necessary information for discussing future economic cooperation and establishing related policies because South Korean firms could play an important role in economic cooperation between the two Koreas.

There are few previous empirical studies that analyze the performance of firms using KIC internal data (KICOX, 2010; Sukki, 2007) and survey data for those firms that have been part of the complex (KDI, 2008; Hoon, 2007; Dong et al., 2008). As an exception, Jung (2015) studied the performance of KIC firms and found that participation of KIC has no effect on the firms' productivity. However, this study is limited in the methodology because the evaluation for the performance of KIC firms is mostly on correlation analysis. Specifically, in comparison with the KIC firms, those firms in the control groups includes all foreign-invested companies, export companies, and strictly domestic invested companies so that firms in control groups are not proper counterfactuals for the KIC firms.

In our study, we restrict firms in the control group to Korean firms that only sell domestically. One of distinguishing features of the firms in the KIC is that they could hire workers at very low wages, making them engaging in pure vertical FDI s, in which the parent company imports all the goods produced in the KIC using very low wage. Thus, the KIC firms are an ideal example of a vertical FDI engaging firms because these firms maximize their profits by establishing local factories to take advantage of the abundant cheap production factors of the host country (Helpman, 1984, 1987; Helpman, 1987). The KIC firms provide a unique opportunity to investigate the role of a pure vertical FDI s because whether a firm engages in a genuine vertical FDI or not is not clearly distinguished by the analytical data in most previous studies.

* Corresponding author: Department of Economics, Korea University, Anam-dong, Sungbuk-gu, 02841, Republic of Korea.
E-mail addresses: nsunion@korea.ac.kr (S. Cho), dwkwak@korea.ac.kr (D.W. Kwak), honglee@korea.ac.kr (H. Lee).

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Table 1
Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.
*l*sales	7,474	23.481	1.240
*l*profit	7,474	13.772	14.750
*l*capital	7,467	20.608	8.294
*l*age	7,474	22.438	11.356
*l*employee	7,140	2.836	2.198
*l*wages	7,453	20.568	1.368
*l*valueadded	2,505	21.411	4.311
*l*prod	4,686	19.325	1.064

The reason is that in most cases firms decide to make investments by considering both the utilization of rich production factors in the host countries along with market access (Markusen, 1995; Hanson et al., 2001). Although theories on FDI are very diverse, most theories have both elements of the use of cheap factors of production and the use of new market access in FDI decisions.

As a result, it is difficult to distinguish between vertical and horizontal characteristics clearly. In practice, most of the FDI decisions of firms are influenced by both factors, so it was practically not possible to isolate the impact on productivity due to the utilization of rich production factors from the effect due to new market access.

Many studies related to vertical FDI have conducted as follows. According to Hayakawa and Matsuura (2011), firms engaging in pure vertical FDIs are more productive than domestic firms because trade costs would make the FDI of purely domestic firms with low productivity unprofitable and only firms with high productive remain profitable after their FDI decision.

Milner et al. (2006) examine the effect of industrial linkages between Japanese firms located in Thailand on pattern of FDI using industry data set constructed from firm-level. The results show that in addition to factor cost advantage such as lower labour cost industrial linkages can leads to agglomeration of FDI. Also Nishitateno(2013) analyzed the relationship between FDI and intermediate export. The result shows that FDI by Japanese upstream firms lead to more exports of intermediate goods from Japan.

Some research present that the presence of domestic competition undermines bargaining power of the foreign parent firms and their ownership shares in the joint ventures with domestic firms (Nakamura and Zhang, 2018). In addition, there is also a study on whether FDI promotion policies can actually attract inward FDI in Japan (Hoshi and Kiyota, 2019).

There are also empirical studies analyzing the relationship between FDI and a firm's productivity and show that a firm's investment decisions reflect productivity levels and that the most productive firms decide to invest abroad, that intermediate productive firms become export companies, and that the least productive firms remain in the domestic market (Helpman et al., 2004).

Similarly, previous studies on the relationship between productivity and FDI examine the mode of investment through estimated productivity such as Olley and Pakes (1996) and Levinsohn and Petrin (2003).

In this paper, exploiting a pure vertical FDI in the KIC, we first examine pre-FDI productivity and firms' FDI decision in the KIC and verify that we could get the same conclusion of high productivity firms are more likely to engage in the FDI as previous studies (Helpman et al., 2004). Second, we examine the impact of a pure vertical FDI on post-FDI productivity. The analysis is unique in that we could isolate the impact of a pure vertical FDIs of firms on productivity due to utilizing cheap labors from the impact from having any access to a new market.

Especially, the analysis of the post-FDI impact on productivity is important because most of the previous studies focused on pre-FDI conditions and the investigations on the change in the productivity of firms after investing in KIC are rather scant. Our study is most closely related to recent two studies that examined the impact of labor cost change on a firm's productivity. Lucht and Haas (2015) examined the effect of the influx of cheap migrant workers on firms' productivity and found that those firms exploiting cheap wage cost by hiring more migrant workers had high productivity. Alvarez and Fuentes (2018) also studied the impact of the change in wage costs using the increase in minimum wage.

They found the increase in minimum wage reduced firm's productivity, which is measured by using various measures for TFP, and also found that the impact is highest in the industries that most heavily rely on unskilled workers. Our study is distinguished from these studies in that the impact of labor cost change is materialized by the introduction of a pure vertical FDI and the identification of causal effect is clean because it is taken place in the KIC area.

For the estimation of the causal effect of a pure vertical FDI on firm productivity, we use an extended version of the difference-in-differences method which is also called as the event study method in Gathmann et al. (2018). We use the KIC firms (i.e., pure vertical FDI firms) as treatment group and firms that only sold to domestic market as the control group, and the introduction of FDI occurred around 2005 for the dataset that spans from 1998 to 2012. As a result, the DID framework becomes our natural choice to analyze the changes in productivity between the KIC and the purely domestic firms before and after the pure vertical FDI interventions in the KIC. We focus on the textile industry, which accounted for the majority of production in the KIC.

We found that the FDI firms in the KIC experienced productivity improvements after investment. The DID results indicate that productivity gain after the intervention is 105 %. This result is consistent with the positive effect of cheap migrant workers on firms' productivity in Lucht and Haas (2015). Further, our event study analysis allows us to examine the dynamic effects of the FDI intervention. For the three years

Table 2
Definitions of variables.

Treatment	Measurements	Explanation
*l*sales	Annual data for log(sales)	Total sales in income statement of each firm
*l*profit	Annual data for log(profit)	Net income in income statement of each firm
*l*capital	Annual data for log(capital)	Tangible asset (total of tangible asset in the statement of financial position)
*l*expenses	Annual data for log(cost)	Cost of Production (freight cost + utility cost + electricity cost)
*l*age	Firm age	Firm age(time between the initial creation of a firm and the present time (in 2014))
*l*employees	Annual data for log (number of employees)	number of employees employed in each firm
*l*wages	Annual data for log(wages)	Total amount of wage of all workers employed in each firm

*Our analysis is based on Kis-value firm database from NICE Information Service Co.

Table 3
Balance tests.

Variable	Sample	Mean		Bias(%)	Reduction	*t*-test	
		Treated	Control		In bias(%)	*t*	P > |t|
*l*sales	Unmatched	23.274	23.622	−38.1		−1.06	0.292
	Matched	23.74	23.644	10.6	72.3	0.16	0.877
*l*profits	Unmatched	16.217	16.49	−2.6		−0.07	0.945
	Matched	20.9	18.264	25.4	−864.7	0.87	0.417
*l*capital	Unmatched	22.8	22.282	68.3		1.3	0.194
	Matched	22.803	22.686	15.5	77.4	0.21	0.84
*l*expenses	Unmatched	15.191	12.712	92.1		**1.67**	0.097
	Matched	15.243	15.054	7	92.4	0.19	0.857
*l*age	Unmatched	25.167	16.207	124		**2.51**	0.013
	Matched	22.5	22.383	1.6	98.7	0.03	0.98
*l*employees	Unmatched	3.6591	2.6012	80.5		**1.69**	0.092
	Matched	3.2023	3.9987	−60.6	24.7	−1.06	0.332
*l*wages	Unmatched	20.629	20.867	−24.7		−0.58	0.562
	Matched	21.113	20.801	32.4	−31.1	0.46	0.662
*Initial*productivity	Unmatched	7.2793	7.4443	−37.8		−0.75	0.455
	Matched	7.3769	7.566	−43.3	−14.6	−0.63	0.554

Table 4
Pre-intervention Productivity.

Dep.Var: Productivity (*l*prod)	Model
treated	0.297 (0.195)
lemployee	0.279*** (0.065)
lcaptal_lintensity	0.383*** (0.046)
Firm size(log total asset)	0.201*** (0.048)
Year effect	Yes
Industry effect	Yes
observation	547

Note: ***, **, * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

after the intervention, productivity gains to the KIC firms were as large as 134 %. However, the effect did not last long. Three years after the intervention, productivity gains for the KIC firms become statistically insignificant.

The paper is organized as follows. First, in Chapter II, we explain the data used in the analysis. In Chapter III, we propose the empirical analysis strategy and methodology. Chapter IV includes our interpretation of the results. Last, in Chapter V, we summarize our findings and offer concluding remarks.

2. Data

The dataset covers firms' data from 1998 to 2012. We transform

Table 5
Results.

Dep Var	(1) lprod	(2) lsales	(3) Log(sales/employee)	(4) lprod	(5) lsales	(6) Log(sales/employee)
Model	Model 1: DID model			Model 2: Event Study Model		
After	−0.062	0.044	−0.019			
	(0.093)	(0.086)	(0.137)			
DID	−0.226	0.182	0.745***			
	(0.225)	(0.219)	(0.278)			
DID(-2)				0.156	−0.073	−0.615**
				(0.236)	(0.224)	(0.253)
DID(-1)				0.144	−0.082	−0.450
				(0.238)	(0.241)	(0.344)
DID(0)				−0.249*	0.014	−0.126
				(0.144)	(0.280)	(0.415)
DID(1)				−0.096	0.026	0.067
				(0.205)	(0.182)	(0.448)
DID(2)				0.153	0.255**	0.871*
				(0.110)	(0.122)	(0.460)
Constant	21.054***	23.537***	19.470***	22.271***	23.517***	19.509***
	(0.048)	(0.034)	(0.043)	(0.052)	(0.037)	(0.054)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.819	0.751	0.512	0.828	0.754	0.517
N	1723	2801	2295	1723	2801	2295

Note: Standard errors are clustered by firm and provided in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. We suppress event year dummy variables to save space. Treatment variable is absorbed by firm fixed effects.

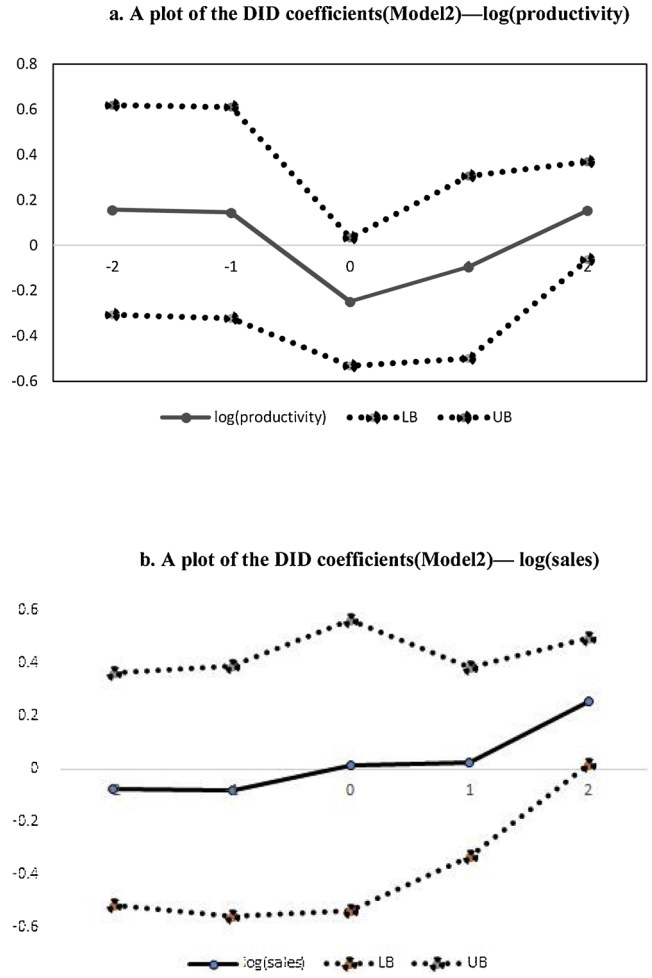

Fig. 1. (a) A plot of the DID coefficients(Model2)—log(productivity) (b) A plot of the DID coefficients(Model2)— log(sales).
Note: 1) The distance between dots indicate 95 % confidence interval.
2) The horizontal axis shows pre- and post-intervention (τ); τ = 0 is the investment year.

annual data to the average of every two years' data to minimize losing information due to intermediate missing data on input factors in productivity estimations.[1] We end up with six event periods; the intervention occurred during the fourth event periods, leaving us two time periods after the intervention.

We restrict the sample coverage to two types of firms–ones engaging in pure domestic sales and ones for which the only foreign destination of FDI is the KIC. There are 37 treated such firms; ten of them are in textiles. Thus, we focus our analysis on these ten textile firms. This helps to maximize the balance between treated and control firms. In the end, we end up with 10 treated and 564 control firms that engage in textile production.

2.1. Dependent variables

The main outcomes are firms' performance measures such as productivity[2], sales, and sales per worker[3] . Particularly, productivity is estimated using the method in Levinsohn and Petrin (2003).

2.2. Control variables

We include firm characteristics, the variables listed in Table 2, as control variables. In all estimations, we include year-fixed effects, event year fixed effects, and firm fixed effects. Descriptive statistics are shown in Table 1, and the definitions for each variable are described in Table 2.

2.3. Treatment variable

Treatment variable is an indicator that have the value of one if a firm even engages in the FDI in the KIC during the sample period and zero if a firm only sell to domestic market during the entire sample period.

Although we already restrict our sample to the firms that are in the textile industry, we further restrict the sample using the matching method to increase the comparability before the intervention. Using the matching method, we improve the data fit and the balance between treated and control firms. We implement the matching using the propensity score matching (PSM) method.

As Helpman (1984, 1987) and Helpnam and Krugman (1987) reported, since more productive firms are more likely to engage in vertical FDI compared to strictly domestic firms, a productivity difference could appear between domestic firms and vertical FDI firms even before the FDI intervention. This difference reflects an initial difference rather than the consequences of engaging in vertical FDI. Thus, using the propensity score, we match the "like-for-like" exporters in two groups, and the variables used for matching them include the initial period values of the productivity measure, which is estimated using the method in Levinsohn and Petrin (2003).

The PSM method requires two assumptions for the estimates to be consistent. The first one is the "ignorability" (i.e., conditional independence) assumption that requires the treatment decision to be independent of the outcome once the propensity score obtained from the observed covariates is accounted for: $(Y_{i0}, Y_{i1}) \perp C_i^N | P(X_i)$. The other is the "overlap" assumption that requires the existence of any comparable firms in the control groups for each treated firm. The comparability between treated and control firms is quantified by the propensity score, which is the predicted probability of being in the treatment group and is estimated using the Probit model where the dependent variable is treatment status and predictors are the characteristics of firms that could also potentially affect their productivity.

2.4. The "ignorability" assumption

A formal test of this assumption is not possible. However, since the variables used for matching include past outcomes, we could look for firms that are as close as possible to treated firms in past outcomes prior to the intervention. Thus, we effectively attribute any deviation of outcome between treated and control firms after the intervention to the effects of the intervention. We implement PSM estimations employing the radius matching method with 0.01 caliper and 10 nearest-neighbor matchings with replacement[4] . For each treated firm, we find matches except for one firm. Thus, in the end we end up with 10 treated and 100 matched control firms that engage in textile production.

[1] Intermediate missing defined as missing only occurs in the middle of year for the whole sample spans. For example, for a firm we observe data during 1996–2000 and not for 2001, but observe again during 2002–2016. However, if we observe data during 1996–2000 but not after 2001 and onward, this is not an intermediate missing.

[2] Productivity is estimated using in Levinsohn and Petrin (2003). When estimating the productivity, value added is used as outcome variable and capital variable is tangible asset. Free variables are number of employee and wage. Proxy variables are electricity cost and utility cost.

[3] The results for other outcomes are represented in the Appendix.

[4] For the sake of simplicity, robust estimations based on the nearest neighbor matching and kernel matching methods are not reported in this paper.

Table 6
Results (Matched).

Dep Var	(1) lprod	(2) lsales	(3) Log(sales/employee)	(4) lprod	(5) lsales	(6) Log(sales/employee)
Model	Model 3: DID model			Model 4: Event Study Model		
After	−0.260	0.263	0.151			
	(0.205)	(0.165)	(0.204)			
DID	−0.243	0.112	0.630**			
	(0.256)	(0.233)	(0.295)			
DID(-2)				0.195	−0.059	−0.626*
				(0.298)	(0.254)	(0.323)
DID(-1)				0.139	−0.071	−0.279
				(0.286)	(0.265)	(0.374)
DID(0)				−0.192	−0.048	−0.259
				(0.188)	(0.301)	(0.438)
DID(1)				−0.104	0.077	0.144
				(0.277)	(0.261)	(0.478)
DID(2)				0.081	0.294*	0.872*
				(0.159)	(0.173)	(0.506)
Constant	20.892***	23.229***	19.182***	22.065***	23.374***	19.392***
	(0.099)	(0.086)	(0.111)	(0.103)	(0.079)	(0.091)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.835	0.710	0.505	0.854	0.718	0.518
N	439	695	561	439	695	561

Note: Standard errors are clustered by firm and provided in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. We suppress event year dummy variables to save space. Treatment variable is absorbed by firm fixed effects.

Furthermore, to assess the quality of the matching, we perform balance tests across the treated and control firms (Table 3). For all of the data, the *t*-test results show some observed variables are significantly different across treated and control firms. Compared to the average of the control firms, the treated firms are greater in age, input costs(*l*expenses), and number of employees, but there is no significant difference in size (*l*sales), profits, wages, and productivity. However, for matched data, we find that these differences disappear after matching. This provides evidence to support the validity for the conditional ignorability assumption for our estimations.

3. Methodology

To explore the influence of vertical FDI participation through the KIC, we use a difference-in-differences (DID) framework. As vertical FDI participation are not randomly selected, there may systematic pre-participation differences in outcome across treated and control firms. The DID estimation can account for pre-participation differences in outcome but it still needs to assume that there is no pre-intervention trend difference across treated and control firms in the outcome variable for a validity of the DID estimation. We attempt to balance better in outcomes across treated and control firms using PSM method. We argue that the DID method will remove any level differences and the matching process removes any pre-intervention trend differences across treated and control firms (if there are any). The main estimation equation is the following:

$$y_{it} = \beta_0 + \beta_1 \text{treat}_i + \beta_2 after_t + \beta_3 DiD_{it} + \beta_4 x_{it} + v_i + f_t + \varepsilon_{it}, t = 1,2, ..,6 \quad (1)$$

where i indicates firm and t is calendar period; we only use matched samples with frequency weights.

$$y_{it} = \sum_{\tau=-1}^{-2} \beta_\tau Event_{i,t}^{\tau} + \sum_{\tau=0}^{2} \gamma_\tau Event_{i,t}^{\tau} + Z_{jt}^{1}\pi + \theta_\tau + v_i + f_t + \varepsilon_{it} \quad (2)$$

where i indicates firm, t is calendar period, τ is event period. $\tau = 0$ is the period that FDI investment intervention occurs, and $\tau = 1$ is the first post-intervention period. β_τ and γ_τ are the main parameters of interests. The outcome variables we examine for firm performance include productivity, sales, and sales per employee[5] .

One important difference for the event study from the DID method is that the estimates for β_2 in Eq. (1) are decomposed into three coefficients of γ_τ for $\tau = 0,1, 2$ in Eq. (2). Furthermore, the event study method allows us to formally test the differential pre-intervention trend across treated and control firms using joint test on β_τ in the Eq. (2). The null hypothesis is β_τ for $\tau = -1, -2$ is zero. We found that in all estimations, we cannot reject this null hypothesis. We also examine the pre-intervention productivity difference across treated and control firms using the following equation:

$$\text{lprod}_{it} = \beta_0 + \beta_1 \text{treated}_i + \beta_2 Z_{it} + v_k + f_t + \varepsilon_{it} t = 1,2, 3 \quad (3)$$

where $\beta_1 > 0$ implies that the KIC firms had higher productivity level compared to purely domestic firms; *treated* is a dummy variable for treated groups and v_k is industry fixed effects. Z is a vector of firm-specific variables. These variables include capital intensity (measured as the ratio of the capital stock to the number of employees), logarithm of number of employment, firm size dummy (i.e. indicator of small-medium size firms so it has the value of zero for large firms). In the choice of predictors in Eq. (3), we follow Fazlıoğlu et al. (2018).

4. Results

4.1. Pre-intervention productivity

We estimate the Eq. (3) using the pooled OLS method from 2000 to 2004. The results are reported in Table 4. The coefficient estimate for

[5] The other output variables are presented in the Appendix.

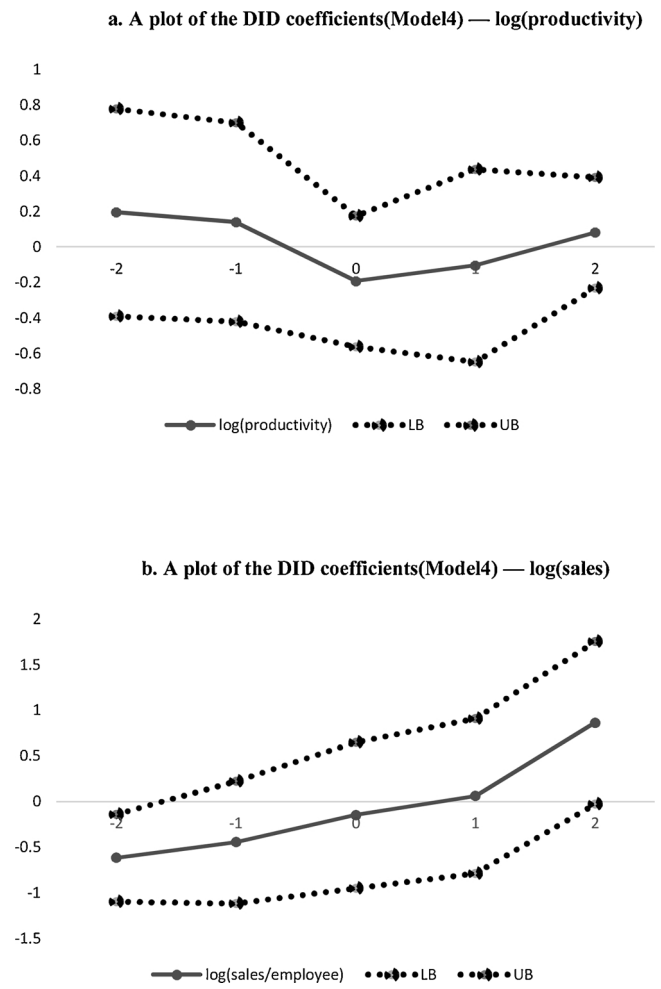

Fig. 2. (a) A plot of the DID coefficients(Model4) — log(productivity) (b) A plot of the DID coefficients(Model4) — log(sales).
Note: 1) The distance between dots indicate 95 % confidence interval.
2) The horizontal axis shows pre- and post-intervention (τ); τ = 0 is the investment year.

treated group is positive but not statistically significant. In Table 4, the result shows that, among those treated and control firms, large (in sales), capital-intensive, and greater (in the number of employees as well as total assets) firms are the firms with the high productivity level.

4.2. Post-intervention productivity

We estimated Eq. (2) via Models 1 and 2, which are presented in Table 5. Model 1 report the results estimated by difference-in-differences (DID), and Model 2 extends the basic DID model to the event study framework. For the Model 1 estimations, in column (1), we find no significant effect on productivity for *DID* coefficient. On the other hand, in column (3), we find significant positive effect on sales per worker.

This result indicates that the Kaesong investment firms increased their sales per worker but this improvement in sales had not linked to the productivity improvement. In Model 2, for productivity outcome in column (4), all dummy variables that indicate post-intervention year for treated firms are not statistically significant (DID*(1) - DID(2)*). On the other hand, in columns (5) and (6), for the outcomes of sales as well as sales per worker has positively significant coefficients (*DID(2)*). It can be explained that the firms that participated in the KIC experienced increased sales and sales per worker during post-intervention periods but the improvement in sales had not lead to improvement in productivity in the first post-intervention period.

Fig. 1a shows a plot of the DID coefficients on productivity over the years. We can clearly see the changes in the Kaesong investment effect by year through this plot.

The DID coefficient is on the vertical axis. The pre- and post-intervention periods (τ) are represented on the horizontal axis. The distance between the dots is 95 % confidence interval and dots on the solid line are DID coefficient estimates. As can be seen in Fig. 1, the coefficient increased from $\tau = 0$ to $\tau = 2$; however, the effect is not statistically significant. For all periods examined 95 % confidence interval contain zero, the null hypothesis of no effect cannot be rejected. Similarly, in Fig. 1b, we show a plot of the DID coefficients on sales. Sales improved a lot during $\tau = 2$ for Kaesong investment firms.

As mentioned previously, we implemented PSM estimations using the radius matching method with 0.01 caliper and 10 nearest-neighbor matchings with replacement. For each treated firm, we find matches. For the 10 treated firms, we find 100 matched firms in control groups. PSM estimations effectively remove some of comparison firms that rather different in observed characteristics that are used in propensity score estimations.

There is an issue of over-rejection problem in an inference on DID coefficient due to the small number of treated firms as noted by Conley and Taber (2011) and more recently by MacKinnon and Webb (2017) and the citation therein. They show that both in theory and simulation that when the number of clusters (e.g., in our case it is firm) is very small, *t*-test severely over-reject the null hypothesis. In the simulation exercise at Table 3 in p.112 of Conley and Taber (2011), when the number of treatment is 2 and that of control is 98, the size of test from using cluster robust standard error is 0.357 when true size is 0.05. However, for the moderate size of treatment groups such that when the number of treated groups is 10 and that of control groups is 90, the size of test from using cluster robust standard error is 0.095 when true size is 0.05. Recent studies by MacKinnon and Webb (2017) and others also show that not just the number of treatment groups but heterogeneity among groups also contribute over-rejection from *t*-test. In our case, we groups are similar in characteristics as we focus on textile sectors and also try to maximize the balance across groups using PSM method.

The results are reported in Table 6, which are also estimated by DID with matching and event study with matching method as in Gathmann et al. (2018). For Model3's estimates in columns (1) and (2), we found no significant effect for the DID coefficient on productivity as well as sales outcomes but in column (3) DID coefficient is positive and significant for sales per worker at 5 % significance level.

Therefore, matching estimates with fewer observations without outliers we found the same conclusion for the large sample without matching such that the firms experienced improvements in sales per worker by participating in the KIC but this had not leads to productivity improvement. For Model4, in columns (5) and (6) coefficients on *DID (2)* are positive and significant at 10 % significance level. Thus, the firm's sales as well as sales per worker increased after investment in KIC. When we consider over-rejection due to few groups of treatment, this is a weak evidence for a positive performance on sales and sales per worker after the intervention.

The analysis results with matching are provided with visual plots in Fig. 2a, from which we cannot observed any change in the effect of productivity improvement over the years.

On the other hand, in Fig. 2b, we find significant changes in the effect of sales improvement in the post-intervention periods.

5. Conclusion and discussion

The Kaesong Industrial Complex (KIC) was a symbolic economic cooperation between the two Koreas. Beginning in 2004, the KIC was a relatively stable operation in spite of several crises resulting from deteriorating inter-Korean relations, which grew greatly in terms of size until it was shut down.

Presently, whether the KIC will be reopened remains unclear; however, as inter-Korean relations thaw, economic discussions on inter-Korean economic cooperation are being held. The KIC administrative bodies have already reached consensus on business procedures and legislative measures between the two Koreas during its construction phase along with acquiring the unique experience of inter-Korean joint operation. Accordingly, a fundamental evaluation of the KIC can provide insights for enterprises contemplating participation in the KIC. Analyzing the previous performances of firms in the KIC is also of great value as basic information for discussing future economic cooperation and establishing related policies,

Therefore, we examined the effects of participating in the KIC on firms' productivity using firm-level data from 1998 to 2012, focusing on the textile sector. To do this, we implemented PSM estimations employing the radius matching method with 0.01 caliper and 10nearest-neighbor matchings with replacement. We found 100 matched firms in control groups (domestic firms) that corresponded to each of the 10 treated firms.

For analysis, we used a difference-in-differences (DID) framework and extended the basic DID framework to the event study framework of Gathmann et al. (2018). The results reported that the treated firms experienced the increased sales but the improvement in sales had not lead to improvements in productivity. These results can be found in the DID event study as well as the DID analysis. That is, improvement in productivity through FDI cannot be found in the empirical results.

There was government's financial support at the time of investment in KIC. Thus, if there is any change of productivity in the analysis we cannot distinguish between FDI and government support in the effect on productivity. These problems imply that we should focus on the period when government support is over. In the empirical results, we could not find positive effect of productivity over the entire period and the same results hold especially at 2 period(*DID(2)*) when government support is over. Considering these facts, the results in this paper is convincing.

Appendix A

See Table A1 Table A2 .

Table A1
Results (matched).

variables	lvalueadd		lval_p		lprofit		lprofit_p	
	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
after(-1)	−0.392	0.538	−0.483	0.465	1.267	1.327	1.174	1.420
after(0)	0.226	0.585	0.189	0.479	0.500	1.450	0.612	1.581
after(1)	−0.263	0.793	−0.211	0.838	−0.096	1.352	0.914	1.362
after(2)	0.651	0.536	0.727	0.307	0.460	1.315	0.707	1.335
after(3)	0.275	1.265	0.254	1.050	1.601	1.459	1.998	1.421
treated								
DID(-1)	−0.148	0.662	−0.015	0.463	3.335	3.265	2.407	2.623
DID(0)	−0.742	0.744	−0.880	0.596	3.656	3.697	2.920	3.308
DID(1)	0.583	1.048	1.697*	0.953	4.757	3.249	3.404	2.841
DID(2)	−0.528	0.854	−0.348	0.630	−3.171	8.529	−2.560	6.824
DID(3)	0.205	1.403	0.223	1.126	−4.913	8.203	−5.406	7.126
variables	Lemployee		lwage		lwage_p		lsales	
	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
after(-1)	0.029	0.122	0.046	0.067	−0.043	0.088	0.044	0.071
after(0)	−0.148	0.112	−0.071	0.153	0.131	0.090	0.045	0.059
after(1)	−0.060	0.116	0.049	0.074	0.151	0.097	0.053	0.067
after(2)	−0.071	0.112	0.099	0.098	0.041	0.089	0.001	0.070
after(3)	−0.074	0.111	0.060	0.102	0.057	0.102	0.061	0.066
treated								
DID(-1)	0.145	0.138	0.101	0.273	−0.009	0.348	0.210	0.213
DID(0)	0.001	0.561	0.216	0.317	−0.501	0.364	−0.084	0.247
DID(1)	−0.861**	0.451	0.026	0.225	0.422	0.446	−0.022	0.185
DID(2)	0.096	0.220	0.048	0.274	0.056	0.146	0.092	0.210
DID(3)	0.315	0.151	−0.329	0.350	−0.593	0.367	−0.470	0.295
firm size	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
industry effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
obs	601	601	601	601	601	601	601	601

Dependent variables.
Valueadded, per capita valueadded, profit, per capita profit, sales, employment, wage, per capita wage.
Note 1) Robust standard errors are in parentheses.
2) ***, **, * denote significance at the 1 %, 5 %, and 10 % levels, respectively.
3) "*treat*" is omitted by using fixed effect model.

Table A2
Results(matched by PSM).

variables	lvalueadd		lval_p		lprofit		lprofit_p	
	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
after(-1)	−0.011	0.242	0.587	0.321	3.389	2.091	2.911	1.650
after(0)	0.376	0.195	0.660	0.157	−4.675	8.372	−4.625	7.205
after(1)	0.669	0.257	1.236	0.234	−1.958	4.862	−1.351	3.866
after(2)	1.040	0.306	1.291	0.367	−3.157	9.021	−2.813	7.363
after(3)	1.121	0.248	1.600	0.314	−3.453	8.690	−3.422	7.370
treated								
DID(-1)	0.496	0.356	−0.475	0.458	3.296	3.951	2.151	3.039
DID(0)	0.163	0.496	−0.781	0.425	10.850	8.414	9.830	7.261
DID(1)	0.658	0.461	0.840	0.360	8.704	5.558	7.087	4.582
DID(2)	0.221	0.501	−0.083	0.492	1.106	12.752	1.417	10.139
DID(3)	0.471	0.384	−0.410	0.409	0.531	12.218	0.080	10.396

	Lemployee		lwage		lwage_p		lsales	
	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
after(-1)	−0.206	0.205	−0.158	0.159	0.048	0.154	−0.204	0.276
after(0)	−0.350	0.290	0.281	0.140	0.202	0.214	0.173	0.132
after(1)	−0.222	0.183	0.105	0.105	0.290	0.228	0.014	0.166
after(2)	0.117	0.128	0.191	0.122	0.029	0.167	0.039	0.142
after(3)	−0.175	0.163	0.089	0.111	0.157	0.188	−0.119	0.176
treated								
DID(-1)	0.426	0.227	0.291	0.319	−0.134	0.415	0.377	0.323
DID(0)	0.190	0.709	−0.222	0.367	−0.772	0.430	−0.368	0.308
DID(1)	−0.697	0.550	−0.167	0.264	0.068	0.527	−0.186	0.220
DID(2)	−0.097	0.251	−0.090	0.326	0.053	0.165	−0.030	0.255
DID(3)	0.386	0.209	−0.567	0.380	−0.845	0.430	−0.572	0.318
firm size	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
industry effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
obs	167	167	167	167	167	167	167	167

Note 1) Robust standard errors are in parentheses.
2) ***, **, * denote significance at the 1 %, 5 %, and 10 % levels, respectively.
3) "*treat*" is omitted by using fixed effect model.

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