DOES OUTWARD FOREIGN DIRECT INVESTMENT IMPROVE THE PERFORMANCE OF DOMESTIC FIRMS? CASE OF KOREA

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Abstract

In this paper, we use firm-level data in Korea from 2010 to 2019 to analyze whether outward foreign direct investment (OFDI) affects the productivity of domestic firms, known as reverse knowledge spillovers. Using propensity score matching and difference-in-difference regressions, we verify that OFDI improves the productivity of parent companies. Considering the characteristics of OFDI and the parent company, these positive effects become greater when (1) parent company's absorptive capacity (technology level) is high, (2) OFDI is in the M&A form, and (3) OFDI is towards developed countries. In addition to these direct effects, we investigate whether OFDI improves the productivity of other domestic firms within and across industries, known as horizontal and vertical spillovers. The results demonstrate strong evidence of positive vertical spillovers but not horizontal spillovers. These evidences provide important policy implications about the specifics of outward direct investment that are beneficial to capital-exporting countries.

Keyword : OFDI, productivity, reverse knowledge spillovers, absorptive capacity, propensity score matching.

JEL Classification : F21, F23, D22

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1. Introduction

Outward foreign direct investment (OFDI) has dramatically increased in Korea since the 1990s, partly backed by a strong promotion by the Korean government.[1] The OFDI/GDP ratio had been less than 1 percent until the mid-1990s; it increased to 3.5 percent in 1999 and surpassed the amount of inward FDI in 2002. The amount of OFDI reached a record high at USD 64 billion in 2019. As OFDI increases, concerns are growing that relocating production lines overseas could reduce domestic investment and employment. Several studies argue that OFDI is responsible for decreasing exports, domestic investment, and job opportunities.[2] However, on the positive side, OFDI can improve technology at domestic firms engaged in OFDI (defined as 'OFDI firms' or 'parent company' hereafter) by acquiring access to advanced foreign technology.[3]

Positive effects of OFDI typically originate from strategic assets, advanced technology, and natural resources in foreign markets (ESCAP, 2020). This transmission channel is known as "reverse knowledge spillovers," which are based on the following three mechanisms: (1) exposing OFDI firms to new technology, ideas, and managerial expertise in host economies that are not available in a home country; (2) increasing efficiency and reducing production costs by moving production lines to another country with better resources; (3) partnering with foreign host firms to achieve economies of scale, eliminate redundant processes, and accelerate knowledge accumulation by sharing internal assets as well as core business knowledge. Although a large body of literature has examined the effects of OFDI on firm productivity, the literature on when, where, and how OFDI may affect productivity is sparse. Previous literature typically regarded OFDI and parent companies as homogenous and examined the OFDI effects only in the manufacturing sector. Understanding heterogenous OFDI effects based on characteristics of OFDI, destination country, and parent companies still need further investigation.

[1] The Korean government enacted the Foreign Exchange Transactions Act in April 1999 to simplify OFDI procedures and to reduce investment-restricted areas.
[2] For example, Al-Sadig (2013), Herzer (2010), and Jang and Hyun (2015) support the evidence of a "crowding-out effect" on domestic investment by OFDI. In the case of employment, Lee (2010) and Kim (2008) find a negative correlation between OFDI activities and employment in Korea.
[3] Some literature finds evidence for positive OFDI effects using the data of China (Cozza et al., 2015; Huang & Zhang, 2017; Dong et al., 2021), Taiwan (Hsu et al., 2011; Yang et al., 2013), Canada (Rai et al., 2018), and Italy (Imbriani et al., 2011).

In order to analyze the heterogeneous effects of OFDI in Korea, we first construct a comprehensive firm-level dataset that integrates detailed OFDI information in both manufacturing and service sectors in Korea. Then, we use propensity score matching (PSM) and differences-in-differences (DID) approach to avoid a sample selection bias in measuring reverse knowledge spillovers by constructing a comparable control group (domestic firms) for the treatment group (parent company). We consider key factors that can contribute to the heterogeneous effects of OFDI, such as foreign market entry modes (M&A vs. greenfield), destination countries (developing vs. developed), and parent companies' characteristics (absorptive capacity). This analysis can provide clear answers to which characteristics of OFDI and parent companies can explain different productivity effects of OFDI. Finally, we extend our analysis to study whether OFDI generates spillovers to other domestic firms in the same industry (horizontal spillovers) and across different industries (vertical spillovers).

Our empirical results show that there are positive reverse knowledge spillovers from foreign affiliates back to their parent companies. The magnitude of the OFDI effects becomes greater when OFDI is in the M&A form and towards developed countries, because the primary motives for OFDI in the M&A form or towards developed countries are typically related to seeking efficiency and strategy rather than natural resources and foreign markets, which results in positive spillover effects. For parent company's characteristics, OFDI tends to generate more positive spillovers when parent companies have high R&D intensity and are engaged in high-tech industries. In particular, the absorptive capacity of the parent companies plays an essential role in amplifying the positive OFDI effects. Since absorptive capacity is the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends", parent companies with sufficient technology levels can utilize more advanced technology and knowledge abroad (Cohen & Levinthal, 1990). Besides these direct effects, we also find strong evidence of positive vertical spillover effects of OFDI on domestic suppliers that provide intermediate inputs to parent companies, but not of horizontal spillovers in the same industry. Overall, our empirical results suggest that OFDI induces positive reverse knowledge spillovers not only to parent companies but also to domestic firms in the supply chain. On the policy side, we can provide implications on strategies regarding OFDI to maximize positive productivity effects on Korean firms.

2. Trend of outward FDI in Korea

This section analyzes general trends as well as industry-specific characteristics of outward FDI in Korea. Figure 1 presents a general trend of outward FDI in Korea from 1990 to 2020. In 1990, the net OFDI/GDP ratio was 0.36 percent, with 360 new foreign affiliates abroad established by Korean firms. Since then, Korea's OFDI has steadily increased because of the Foreign Investment Promotion Act (FIPA) set in 1994, which raised the net OFDI/GDP ratio to 0.56 percent with 1,384 new affiliates in 1995. However, the OFDI/GDP ratio stagnated between 0.5 and 0.7 percent until 2003 due to various internal and external economic shocks. Korea's OFDI significantly increased as the economy recovered in the mid-2000s. In 2007, the net OFDI/GDP ratio reached 1.77 percent, with the number of newly established affiliates at 6,077, mainly because of the reduced regulations on overseas real-estate acquisition. Since the global financial crisis in 2008, Korea's OFDI declined sharply until 2015 and then began to increase again, reaching a record high of 3.1 percent of the net OFDI/GDP ratio in 2019. However, a surge in OFDI may reflect negative aspects of the Korean economy, as Korean firms escaped from a worsening business environment in Korea, such as lower statutory working hours, a higher minimum wage, and a higher corporate income tax rate.

[Insert Figure 1 here]

To analyze industry-specific characteristics of OFDI, we classify the industries into six sectors: agriculture, mining, manufacturing, services, finance and insurance, and others.[4] As illustrated in Figure 2, the OFDI of Korea has been mainly dominated by the manufacturing and service sectors. The OFDI in manufacturing has grown significantly, from 51 percent in 1990 to 72 percent in 2001. The Korean government advocated OFDI as a key driver for increasing the competitiveness of domestic manufacturing firms by means of technology adoption. Assuredly, there has been a structural change in the share of OFDI in the manufacturing sector from labor-intensive industries, such as leather, luggage, and footwear,

[4] The service sector contains wholesale and retail trade, transportation and storage, accommodation and food service activities, information and communication, professional, scientific and technical activities, business facilities management, and business support services; rental and leasing activities, education, human health and social- work activities, arts, sports and recreation-related services, membership organizations, repair and other personal services, and activities of extraterritorial organizations and bodies. The “others” sector contains real-estate activities, public administration and defense; compulsory social security, activities of households as employers; and undifferentiated goods and services produced by households for their own use.

to capital-intensive industries, such as electronic components, computers, radio, television, and communication equipment. Since 2006, there has been a turnover in the industry structure of OFDI in that (1) the share of the mining sector grew from less than 5 percent to over 20 percent till 2015,[5] and (2) the share of the service sector (including finance and insurance) outweighed that of the manufacturing sector, growing to 49 percent in 2016 and 51 percent in 2020.

[Insert Figure 2 here]

3. Literature review on the effects of OFDI

Unlike the vast literature on inward FDI, few studies have investigated how OFDI affects the productivity of parent companies in their home country. In addition, several studies examining the productivity effects of OFDI in Korea not only provide inconsistent results, but are also limited to case studies, survey approaches, and industry-level data (not firm-specific data) (Lee, 2010; Kim, 2008; Jang & Hyun, 2015). For instance, Lee (2010) argues that the relationship between OFDI and labor productivity in Korea is positive but insignificant, while Jang and Hyun (2015) show a strong relationship between the two variables. Here we provide a literature review on the role of OFDI and explain how the effects of OFDI differ by certain factors, such as market entry mode, OFDI destination, and absorptive capacity of parent companies.

According to Dunning (1980), the motives for OFDI are mainly seeking for natural resources, foreign markets, efficiency, and strategies. That is, the productivity of parent companies can be increased by securing scarce strategic materials, superior technology, management skills, and knowledge acquired from their affiliates in the host economy. These positive effects can be acquired through several channels, such as market expansion, sharing of information and technological innovation, and learning effects.

Many researchers have demonstrated a positive role of OFDI in increasing productivity of parent companies by means of efficient use of resources (Bertrand & Betschinger, 2012; Görg et al., 2008) or reallocation of production lines according to intra-firm specialization and

[5] A rise in oil prices and expansion of resource nationalism pressured Korean firms to secure foreign raw-material sources actively.

economies of scale (Cozza et al., 2015; Ramcharran, 2012). Combining the parent company's production plant with foreign plants can improve the competitiveness in domestic and foreign markets by sharing internal knowledge assets and increasing the production of final products at lower costs (Desai et al., 2005; Herzer, 2010; Imbriani et al., 2011). Furthermore, parent companies can acquire new technologies and knowledge, for example, by establishing R&D centers in a knowledge-intensive environment (Yang et al., 2013) or by locating affiliates close to leading R&D centers (Pearce, 1999). Similarly, ESCAP (2020) and Rai et al. (2018) argue that OFDI abroad can increase the productivity of parent companies by accumulating knowledge learned from best practices, efficient skills, and know-how in host countries. This, in turn, allows parent companies to overcome the lack of advanced technology in their home countries and improve performance by taking advantage of such strategies (Child & Rodrigues, 2005; Fu et al., 2018; Kunc & Morecraft, 2010; Tang & Altshuler, 2014). Such acquired new knowledge and ideas are typically transferred from affiliates to their parent companies by means of multinational internal networks (Huang & Zhang, 2017). Accordingly, OFDI can be regarded as a significant source of global knowledge and technology flows between parent companies and their affiliates.

3.1 OFDI and absorptive capacity of parent company

The scale of OFDI effects can depend on the nature of parent companies. Many researchers emphasize the role of absorptive capacity, which plays a crucial role in determining how much a parent company can benefit from OFDI (Huang & Zhang, 2017; Jang & Hyun, 2015; Li et al., 2017). Absorptive capacity speeds up the realization and application of new knowledge into practice (Vu, 2018). Specifically, even if OFDI affiliates acquire new knowledge and technological know-how abroad, parent companies with low technological capacity cannot fully absorb such external knowledge. Deng (2010) argues that accumulating knowledge by combining sources of external and internal knowledge is greater than doing external or internal activities alone. Jang and Hyun (2015), using Korean industry-level data, show that OFDI enhances domestic productivity, especially in industries with a high comparative advantage. In line with this proposition, Kunc and Morecraft (2010) argue that parent companies with strong R&D capabilities can accelerate activities that create added value and increase competitiveness. Therefore, parent companies must have enough absorptive capacity to adopt and utilize these strategic assets domestically and expand the innovation capacity of OFDI (Filippetti et al., 2017). Panibratov and Fitzpatrick (2020), Pedro et al. (2014), and Tang and Altshuler (2014) also claim that more sophisticated and complex knowledge can be assimilated if the parent company has sufficient absorptive capacity. Consequently, the potential benefits of OFDI-related productivity effects may depend on the absorptive capacity of the parent company, which determines the scale of recognizing, learning, and applying advanced technology transmitted from foreign affiliates (Cohen & Levinthal, 1990).

3.2 OFDI and foreign-market entry mode

OFDI can enter the host country in different modes, for example, in the form of M&A or greenfield investment.[6] Several studies have shown that M&A motives are likely to seek strategic and efficient assets, whereas greenfield investment motives are mainly driven by natural resources and market expansion. In this regard, OFDI in the M&A form can better magnify the reverse knowledge spillovers than greenfield investment (Edamura et al., 2014; Jovanovic & Rousseau, 2008; Ranft & Lord, 2002). For instance, Stiebale and Trax (2011) show that OFDI in the M&A form improves the productivity of parent companies by acquiring complementary assets and technologies, whereas greenfield investment does not allow direct access to foreign knowledge. More precisely, the combination of existing ideas and partner's new knowledge further increase the efficiency of the acquired firms (Bertrand & Zuniga, 2006). Furthermore, cross-border M&As allow parent companies to quickly gain insight into consumer demand in the host economy and reduce the cost of finding reliable suppliers, distributors, customers, and even competitors in the host economy (Boateng et al., 2008). However, the positive effects of M&A-type OFDI are not always realized. Bertrand and Betschinger (2012) find that the performance of M&A firms can be reduced because of new integration and organizational costs.[7] In research projects, overlapping acquirers and target companies can reduce internal R&D activity after mergers (Cassiman & Veugelers, 2006). In addition, since the greenfield OFDI typically launches new business activities in foreign markets based on the knowledge transmitted from their parent company, the affiliates with

[6] The M&A form means that the domestic parent company owns 51-98% of the equity of existing foreign affiliates, whereas the greenfield type establishes a subsidiary in a foreign country, building its operations from the ground up.

[7] Specifically, the post-merger firms incur the cost of coordination for integrating the merged firms into the operation and management mode of the parent company in terms of culture, production, brand, personnel, etc. (Zámborský et al., 2021).

sufficient knowledge can be easily embedded in the host economy and become self-sufficient in knowledge creation (Cantwell & Mudambi, 2005).

3.3 OFDI and destination country

Reverse knowledge spillovers from OFDI are likely to occur in advanced economies with abundant technological endowment and managerial expertise. Since the first phase in reverse knowledge spillovers is to acquire knowledge assets in the host economy, investing in advanced economies provides more opportunities to use local research clusters and high-skilled workers (Child & Rodrigues, 2005; Cozza et al., 2015; ESCAP, 2020). Using firm-level panel data of the Taiwanese manufacturing sector, Hsu et al. (2011) find that the effects of OFDI differ according to destination countries and that the positive effects are amplified, especially in the strategic asset-seeking OFDI. De la Potterie and Lichtenberg (2001) also show positive productivity effects from OFDI towards developed economies where R&D is concentrated. This is because OFDI towards developing countries mostly aims at lowering production costs and increasing resources, whereas OFDI in advanced countries is designed for leading technology, high-skilled workers, and knowledge frontiers (Dong et al., 2021; Fu et al., 2018; Lee, 2010; Panibratov & Fitzpatrick, 2020). Moreover, OFDI in developed countries not only has access to specialized resources but can also utilize well-developed institutional systems and institutional structures, such as the enforcement of property rights, supply of advanced financial systems, and effective innovation systems (Li et al., 2017).

4. Data

4.1. Description of the dataset

This study uses a detailed firm-level dataset drawn from both Survey of Business Activities (Korean parent companies) and Survey of Business Activities Affiliates (OFDI activities) provided by the Korean National Statistical Office. The former set collects data from an annual survey of Korean companies over the period 2010-2019 and provides comprehensive information on a wide set of economic and financial variables, including gross sales, the number of employees, intermediate inputs, tangible and intangible assets, investment amount, and the number of affiliates.[8] Accordingly, the database allows us to estimate the total factor

[8] All Korean companies with at least 50 full-time workers and more than 300 million KRW in the capital are

productivity (TFP) of an individual firm operating in manufacturing and service sectors. The manufacturing and service sectors are divided into 48 industries classified by the Korean Standard Industry Code (KSIC) at the two-digit level.[9] However, this unique firm-level dataset does not cover enough OFDI information except for the number of affiliates abroad and the transactions between parent companies and their foreign affiliates.

On the other hand, the Survey of Business Activities Affiliates contains firm-level data on Korean companies' foreign affiliates, bridging the information gap between OFDI activities and Survey of Business Activities. It provides abundant information on micro-level OFDI data, such as shares of foreign capital investment, investment amount, industrial code, and OFDI destination. We carry out data linkage processes to combine information on OFDI activities from different sources for the same entity based on a unique set of company identifiers (corporate panel key).[10] Therefore, the final firm-level dataset can identify the productivity effects of OFDI and factors that drive heterogenous OFDI effects, such as market entry mode, host destination, and the natures of the parent companies. This left an unbalanced sample of 19,771 observations for domestic firms, parent companies doing OFDI, and affiliates abroad.

The following sampling criteria were used to eliminate outliers prior to doing the empirical analysis: (1) removing missing or zero values; (2) including only companies in the manufacturing and service industries; and (3) removing financial data that violates generally accepted accounting principles (GAAP).[11] In order to control inflation, we deflated the relevant variables using appropriate deflators provided by the Bank of Korea. For instance, gross sales, fixed assets, intermediate inputs, R&D expenses, total sales within affiliates, and purchases within affiliates were deflated by the producer price index (PPI) of the manufacturing and service sectors at the two-digit industry level. We use the export price index and import price index to adjust the direct and indirect export and import amounts to real terms. Total factor productivity (TFP), which measures the productivity level of each firm, is estimated by two commonly used methods: the semi-parametric approach developed by Levinsohn and Petrin

included.

[9] We rule out the firms operating in the financial and real-estate sectors.

[10] The Korean National Statistical Office's official corporate registration system assigns unique company identifiers (corporate panel key). According to Huang and Zhang (2017), the data linkage based on a unique corporate code is more reliable because companies sometimes change their names, confusing data processing.

[11] For example, GAAP violations are total sales less than intermediate inputs, fixed assets greater than total assets, and companies with fewer than 50 employees.

(2003) and the OLS estimation method.[12] The data processing generates a panel dataset of 58,816 observations over the period 2010-2019.

4.2. Descriptive statistics

Table 1 shows the main descriptive statistics of OFDI and non-OFDI (domestic) firms from the entire sample (1st and 2nd columns). The 3rd and 4th columns show the same statistics after PSM treatment as described in the next section. There are obviously systematic differences between the two groups. In terms of productivity, OFDI firms are 1.03 times more productive than are domestic firms. OFDI firms are more than 1.14 times larger than are domestic firms. Statistics for OFDI firms show greater capital, R&D, and export intensity. Especially, when comparing export intensity variable in whole and PSM treated samples, the difference in export intensity between domestic and OFDI firms is about 0.13, whereas the difference is reduced to 0.03 after the matching. So, we can safely argue that the trade effects are removed when measuring the OFDI effects on productivity.[13] In addition, OFDI firms are superior to domestic firms in outsourcing R&D activity with the affiliates and the number of patents developed by overseas affiliates, at 8.79 and 1.55 times that of domestic firms, respectively. Strategic assets may be transferred between parent companies and their affiliates by means of intra-firm networks. This is confirmed by the intra-firm transactions data---gross sales, exports, and imports---which are higher in OFDI firms.[14] This observation implies that OFDI improves the productivity of parent companies by transferring new technologies and knowledge from their affiliates through multinational internal networks.

[Insert Table 1 here]

[12] Unlike the OLS estimation approach, the semi-parametric method can address simultaneity bias arising from the correlation between the input choice and unobserved productivity shocks (Levinsohn & Petrin, 2003).

[13] Firms with high export intensity may absorb more knowledge spillovers from OFDI by taking advantage of access to foreign distribution network and information of foreign markets that they already acquired through exporting. Therefore, whether the OFDI firms were originally domestic firms or exporting firms before OFDI may affect results.

[14] This is in line with the argument of Huang and Zhang (2017), Jang and Hyun (2015), and Rai et al. (2018), who suggest that the intra-firm network is an important mechanism for transferring reverse knowledge to parent companies.

5. Estimation strategy

5.1. Sample selection bias and treatment approach

Potential OFDI firms (parent companies) can be *ex-ante* different from non-OFDI firms (domestic firms) before they invest in OFDI. As illustrated in Table 1, OFDI firms are larger than non-OFDI in terms of firm size, export intensity, productivity, and gross sales. Therefore, when the productivity of parent companies increases, it is unclear whether this is driven by an OFDI effect or whether they are already more productive than are other firms regardless of OFDI.[15] If such sample selection bias is not properly addressed, the endogeneity and (reverse) causality bias in estimating the OFDI effects may produce biased and inconsistent results.

This study attempts to solve the sample selection bias by applying propensity score matching (PSM). The basic idea of the PSM is to construct a control group (domestic firms) that is most similar to the treatment group (parent companies) before engaging in OFDI based on a range of observable characteristics. In this way, we can capture differences in productivity between matching pairs as a real effect of OFDI. That is, we select the firms who undertook OFDI for the first time in a specific year as the treatment group and select the control group that has similar characteristics as the treatment group but did not invest in OFDI.

In detail, the propensity score is calculated using a logistic regression model in a given year. For example, the propensity score for the year 2013 is as follows: $PS(x) = Prob\left(OFDI\ I_{i,t=2013} = 1 \,\middle|\, X_{i,t-1=2012}\right)$, where the dependent variable ($I_{i,t=2013}$) is a dummy variable that is 1 if firm i invests abroad for the first time in 2013, and 0 otherwise. The explanatory variables ($X_{i,t-1=2012}$) stand for the set of firm characteristics that affect the probability of engaging in OFDI and firm productivity, including TFP, firm size, intermediate input cost, capital intensity, and R&D intensity, as well as a full set of two-digit industry and year dummies.[16] Firms in heavily competitive industries may be more productive than others, so the Herfindahl–Hirschman Index (HHI) is also included in the estimation model to control for competitive effects. Note that all explanatory variables are lagged by one year to control

[15] These findings are mentioned by Helpman et al. (2004), who show that larger and more productive firms tend to undertake OFDI, known as the self-selection effect.

[16] Dummy variables can control unobservable industry-specific and year-specific factors that may affect the correlation between firm productivity and OFDI.

for the pre-OFDI characteristics of firms, in this case at the year 2012.

The counterfactual is constructed by selecting the control group with the characteristics closest to the OFDI firm (treatment group) using the estimated propensity score of each firm. That is, the treatment group and control group should be matched within the nearest estimated propensity score values of $PS(x)$, and the distributions of $X_{i,t-1=2012}$ must be nearly identical to each other. To find the appropriate control group, we employ a one-to-one nearest neighbor matching with a caliper of the width less than 0.03 such that $C(i) = \min_j\{|PS(X_i) - PS(X_j)|\} < 0.03$, where $C(i)$ represents a set of non-OFDI firms that match the jth OFDI firm with the propensity score value of $|PS(X_i) - PS(X_j)|$ less than 0.03.[17] The control group should belong to the same year and same industry at the two-digit level as the treatment group to avoid the industry and year biases.

To assign a counterfactual treatment date to the control group, we use the proportional-random investment time assignment approach adopted in Cozza et al. (2015) and Huang and Zhang (2017). Using this approach, we chose 2013 as the base year when the largest number of firms started as the first-time OFDI firms; 450 firms (14.2% of total OFDI firms) started OFDI for the first time in 2013 and selected the same number of firms from the control group based on their propensity scores.

To evaluate whether the matching procedure is properly conducted, we compare the kernel density function of matching variables for the treatment and control groups. Figure 3 depicts the kernel density functions for the two groups before (left panel) and after (right panel) matching in terms of propensity scores.[18] Compared to the density functions before matching, the density distributions of the two groups are more similarly distributed after matching, which validates our matching procedure. In other words, when the two groups are well balanced, OFDI effects can be accurately measured in isolation from other factors not related to OFDI.

[Insert Figure 3 here]

[17] According to Austin (2011), we use a caliper width of 0.03, obtained by multiplying the standard deviation of the propensity score by 0.2. Specifically, the standard deviation of the propensity score in this paper is 0.132, so the caliper width is equal to 0.03 (= 0.132*0.2).

[18] To reaffirm the success of the matching procedure, we additionally perform the kernel density tests on TFP, firm size, export intensity, and R&D intensity, which are available upon request.

Another way to verify whether matched pairs are effectively balanced across observable characteristics is to conduct a paired t-test for the equivalence of means in the treatment and control groups before and after matching. As illustrated in Table 2, all selected variables in the treatment group are larger than those in the control group before matching, and the differences between the two groups are statistically significant at the 1% level. After applying the PSM, most covariates show similar mean values between the two groups, showing that the balancing condition is satisfied in the matched pairs. More specifically, the paired t-statistics show no statistically significant differences between the two groups, except for the R&D intensity, which is different at a 5% significance level.[19] We confirm that there are no systematic differences in the distribution of covariates between the two groups after matching.

[Insert Table 2 here]

We also compare the Pseudo R^2 and LR tests obtained from logistic regression before and after matching, as reported in the last two rows in Table 2. The LR test shows a statistically significant effect before matching but not after matching, suggesting that at least one explanatory variable affects the firm's OFDI decision-making before matching. The Pseudo R^2 is an indicator of how well explanatory variables explain the probability of engaging in OFDI (Cozza et al., 2015); it shows a much lower value of 0.03 after matching compared to 0.13 before matching, which implies that the logistic regression does not have statistically significant explanatory power after matching. Taken together, the balancing test results show that we have successfully removed the sample selection bias by using the PSM.

5.2. DID least-square dummy variables (LSDV) approach

Following the methodology used in Dong et al. (2021), Huang and Zhang (2017), and Rai et al. (2018), we combine the DID method with the PSM to estimate the direct causal effects of OFDI on the productivity of firms (PSM-DID approach). We first run the regression of the total factor productivity (TFP_{ijt}) on three variables: OFDI effect ($Treat_{it}$), self-selection ($Self_i$), and

[19] In addition, we considered only the R&D intensity variable in the PSM approach to form the control group similar to the treatment group in terms of R&D intensity as much as possible. After reapplying the PSM, we find that the paired t-statistics for the R&D intensity is not statistically significant anymore. Although the results are not included in the paper, the OFDI-related productivity effects are still positive and significant except for TFP2 case. These results imply that even after removing the R&D effects, OFDI still produces positive effects on productivity.

time ($Time_t$) as follows:

$$TFP_{ijt} = \alpha Self_i + \beta Treat_{it} + \gamma Time_t + \eta_i + \alpha_j + \delta_r + \varepsilon_{ijt} \quad (1)$$

where subscripts *i, j, r,* and *t* stand for firms, industry sectors, regions, and year, respectively. TFP_{ijt} is the log of total factor productivity of firm *i* operating in sector *j* at year *t*, which is calculated by the Levinsohn-Petrin approach and the OLS estimation as explained in the previous section. $Self_i$ is a dummy variable representing the self-selection effect, which equals 1 if the firm belongs to the treatment group prior to OFDI and 0 if never invested abroad. Thus, the coefficient α measures the productivity difference between OFDI and domestic firms before engaging in OFDI. $Treat_{it}$ is a dummy variable that captures the reverse knowledge spillovers from OFDI, which equals 1 in the post-OFDI years by the treatment group and 0 otherwise. The coefficient β indicates changes in the average productivity effects for the two groups during both pre- and post-OFDI periods.[20] A positive β indicates that OFDI has positive reverse knowledge spillovers on the performance of parent companies. We also include a time dummy variable, $Time_t$, for distinguishing pre- and post- OFDI periods, which takes 1 in 2013 and afterwards, and 0 otherwise. Thus, the coefficient γ controls the common year effects for firm i during the OFDI year and onwards. Finally, firm (η_i), industry (α_j), and region (δ_r) dummies[21] are added in the specification, since unobservable firm-, industry-, and region-specific factors may affect the correlation between firm productivity and OFDI presence.

6. Baseline estimation results

6.1. Results from the whole sample

Panel A of Table 3 reports the baseline results with three dependent variables: (A-1) TFP estimated by the Levinsohn-Petrin approach (TFP1); (A-2) TFP from the OLS estimation (TFP2); (A-3) real gross sales (Gross sale); (A-4) number of patent applicants (Patents). Estimation results show that the coefficients for the *Self* variable are positive and statistically

[20] $\beta = E(\beta_{it}|OFDI_{it} = 1) = \left(E\left(\Delta lnTFP_{it+1}^{OFDI}|OFDI_{it+1} = 1\right) - E\left(\Delta lnTFP_{it}^{OFDI}|OFDI_{it} = 1\right)\right) - \left(E\left(\Delta lnTFP_{it+1}^{Domestic}|OFDI_{it+1} = 0\right) - E\left(\Delta lnTFP_{it}^{Domestic}|OFDI_{it} = 0\right)\right)$

[21] The regional dummies (θ_r) consists of 12 regions, including Seoul, Busan, Daegu, Incheon, Daejeon, Ulsan, Gyeonggi-do, Chungbok, Chungnam, Jeonnam, Kyungbok, and Kyungnam.

significant at the 1% level, which confirms that larger and more productive firms tend to self-select into OFDI. The coefficient of the most important variable, *treat,* is significant and positive at the 1% level for all specifications, suggesting that investing in OFDI significantly increases the productivity and output at home. Specifically, the increase in OFDI enhances the productivity of parent companies by 9.5% compared to domestic firms based on the result in column 1 of Table 3.[22] As is evident in the descriptive statistics in Table 1, the OFDI firms have more patents developed by their affiliates and higher intra-firm imports than domestic firms after invested in OFDI.[23] It proves that strategic assets developed by Korean affiliates are transferred back to parent companies.[24]

[Insert Table 3 here]

To confirm the robustness of these findings, we estimate whether the OFDI effects are observed in different base years other than 2013. The last three columns present the estimation results with the base years 2014, 2015, and 2016.[25] All coefficients for the *treat* are significantly positive for all three years. These results reinforce the findings of the benchmark case in Panel A, which assures positive effects of OFDI on the performance of parent companies. To be more specific, the coefficient on the *treat* with the base year 2016 is higher than that of other periods. This can be attributed to the rapid growth of OFDI in 2016 and an increase in the proportion of M&A-type OFDI, which can generate relatively bigger reverse knowledge spillovers (The Export-Import Bank of Korea, 2018). Overall, the results in Table 3 show that OFDI plays a crucial role in facilitating the productivity of parent companies regardless of the year when OFDI is first initiated.

[22] For the log-transformed dependent variable with a dummy, the impact of *treat* on TFP1 is calculated as 100*(exp(β)-1) when the treat variable is switched from 0 to 1. Following this formula, investing in OFDI improves the productivity of parent companies by 9.5% (=100*(exp(0.091)-1)) more compared to domestic firms.

[23] Before OFDI investment, parent companies have 1.4 times more patents, but pure domestic firms have 5.9 times more intra-firm imports than the parent companies. But these two variables of parent companies have 1.5 and 7.2 times higher than those of domestic firms after OFDI investment, respectively.

[24] This is also supported by the statistics that about 73% of parent companies are entering overseas technology alliances in the same sector through OFDI.

[25] Our dataset shows that 51 firms invested abroad for the first time in 2014, 23 firms in 2015, and only 11 firms in 2016.

6.2. Sub-sample results

In this section, we use various sub-samples based on the characteristics of parent companies and examine whether the estimation results would change depending on these characteristics. We use three criteria: industry classification, factor intensity, and productivity level. The first row in Table 4 shows the average TFP levels of each group, and the remaining rows display the estimation coefficients from equation (1). First, Panel A displays the OFDI effects by industry classification, whether the firm belongs to the manufacturing sector or service sector. The coefficient on the *treat* variable in the service sector is 3.7 times bigger than that from the manufacturing sector, indicating that reverse knowledge spillovers are bigger in the service sector. However, the sample size in the service sector is quite small, at 50 compared to 850 firms in the manufacturing sector, so it would be hard to interpret this result as a general phenomenon.

[Insert Table 4 here]

Second, Panel B reports estimation results based on the parent firms' factor intensity in four categories: R&D, capital, export, and labor intensities.[26] Estimation results show that parent companies with high R&D intensity have statistically significant positive OFDI effects, whereas the three factor intensities do not make significant differences in the OFDI effects. This finding is supported by the study of Deng (2010), who asserts that the productivity improvements by OFDI do not occur automatically but through means of synergies between in-house R&D activities and external knowledge acquired from OFDI. Finally, in order to verify the role of technology in determining the OFDI effects, we classify parent companies' industries according to their technology level into high-tech, medium-tech, and low-tech industries. Panel C shows that the estimation coefficients for parent companies in the high-tech industries are relatively high, whereas these coefficients are either small or insignificant for medium-tech and low-tech industries. These results are consistent with those of Panels B for R&D intensity. Taken together, parent companies in high-tech industries and with high levels of internal R&D utilize more positive OFDI effects.

[26] Definitions of factor intensities are described in Table 1. We select high intensity firms as those with higher values than the sample average.

7. Estimation results with extended models

While the previous section investigates the OFDI effects using sub-sample analysis, this section extends the benchmark empirical model to formally examine key factors that generate heterogeneous OFDI effects. Since the natures of OFDI and parent companies are not homogeneous, the magnitude of the OFDI effect may depend on the underlying factors, such as motives for OFDI and the absorptive capacity level. To evaluate how such factors affect the potential OFDI effects, we add an interaction term between the factors that illustrate heterogeneous characteristics and the OFDI effects (*treat*) in the estimation equation as follows:

$$TFP_{ijt} = \alpha Self_i + \beta Treat_{it} + \varphi(Treat_{it} * F_{it}) + \delta F_{it} + \gamma Time_t + \eta_i + \alpha_j + \delta_r + \varepsilon_{ijt} \quad (2)$$

Note that $\beta + \varphi$ measures how much the magnitude of the OFDI effect depends on the underlying factor F_{it}. Therefore, if $\varphi + \beta > \beta$, then the factor F_{it} plays a crucial role in amplifying the OFDI effect.

7.1 Absorptive capacity of parent company

Based on the results in Section 6, that parent company's internal R&D activities and technology level are important factors in determining the OFDI effects, this section verifies those results by measuring how absorptive capacity affects OFDI. First, we develop three proxies that measure the absorptive capacity of a parent company. The first proxy for absorptive capacity is a ratio of TFPs between a firm and the industry leader, measured as $Abs_{ijt} = \frac{TFP_{ijt-1}}{Max(TFP^{OFDI}_{ijt-1})}$, where TFP_{ijt-1} indicates the TFP of firm i operating in sector j at year *t-1*, and $Max(TFP^{OFDI}_{ijt-1})$ denotes the maximum TFP value of the firm doing OFDI in the same sector and year.[27] As a second proxy, following Huang and Zhang (2017), we measure an absolute difference of technical efficiency (TE)[28] from the industry average, measured as $Tech.gap_{ijt} = TE_{ijt} - TE^{OFDI}_{jt}$, where TE_{ijt} is the firm-level TE and TE^{OFDI}_{jt} represents the industry average TE of OFDI firms weighted by a firm's total assets. Similar to the second proxy, we also

[27] This method is from the studies of Girma (2005), Han and Kim (2020), and Kim (2015).
[28] The firm-specific technical efficiency (TE), which produces the maximum output from the minimum quantity of inputs, is estimated by a stochastic frontier production function following Battese and Coelli (1988).

experiment with the third proxy $TG_{ijt} = \frac{TE_{ijt} - TE_{jt}^{OFDI}}{TE_{jt}^{OFDI}}$, following the study of Vu (2018), which measures the percentage difference of TE from the industry average. For all three proxies, a higher value implies that a firm's productivity is high.

Table 5 shows the estimation results of equation (2) with three proxies for absorptive capacity (panels A, B, and C) with TFP1 and TFP2. In Panel B and C, the coefficients on the stand-alone *treat* variables are still positive and highly significant, indicating OFDI has positive effect on the productivity of parent companies without absorptive capacity. The coefficient of interaction term between *treat* and absorptive capacity variables, however, shows a statistically greater value in all specifications except column (A-2). More explicitly, the coefficient of interaction term is approximately 3.73 times higher than the stand-alone *treat* variables in column (C-1). This evidence strongly supports that absorptive capacity is essential for firms to recognize and understand their affiliates' knowledge, skills, and technology. This result is in line with the results in Table 4, which shows that a high level of internal R&D activities is a prerequisite for efficient use of reverse knowledge spillovers from OFDI. In sum, we reconfirm that the internal R&D activities and technology level as well as the absorptive capacity of parent companies are the most significant factors in amplifying the OFDI effects.

[Insert Table 5 here]

7.2 OFDI characteristics: foreign-entry mode and destination

The natures of OFDI may affect the scale of reverse knowledge spillovers as the mode of entering the foreign markets depends on the motives, internal and external costs, and risk exposure of parent companies (Zámborský et al., 2021). As previous literature, we first construct the entry-mode dummy variable using the following criteria. When the parent company has a stake in foreign affiliates between 51-98 percent, we classify such OFDI as the M&A form. If such holdings are over 99%, then they are classified as greenfield OFDI. To examine whether foreign-entry mode can influence the OFDI effects in a heterogeneous way, we run regressions with dummy variables for OFDI entry mode. Then, we estimate equation (2) using interaction terms between the foreign-entry mode dummy (M&A or greenfield) and the OFDI effect (*treat*). Column A in Table 6 shows the estimation results based on M&A (A-

1) and greenfield (A-2) OFDI dummies.

[Insert Table 6 here]

Column (A-1) reports that the *treat* variable and the interaction term between the M&A dummy and *treat* are both positive and statistically significant at the 5% level. The scale of the interaction term coefficient is slightly greater than the stand-alone *treat* variable, which implies that OFDI in the M&A form makes a more positive contribution to the productivity of parent companies. Economically, the form of M&A OFDI boosts the productivity of the parent company by 8.5% compared to the non-M&A OFDI.[29] This is in line with Ranft and Lord (2002), who find that the parent companies merged with foreign companies can better access the internal knowledge of their partner firms and quickly accumulate information about host markets. In contrast, a strikingly different pattern is found for greenfield OFDI. As shown in column (A-2), the coefficient for the interaction term is statistically significant but negative. Greenfield OFDI reduces the productivity effects because the motive for greenfield investment is to exploit existing firm-specific assets or differences in production costs between countries rather than access foreign knowledge (Bertrand & Zuniga, 2006; Edamura et al., 2014; Stiebale & Trax, 2011). It can be concluded that M&A form is more effective in amplifying OFDI effects than greenfield OFDI.

In Panel B, we explore the heterogeneity of reverse knowledge spillovers based on OFDI destination countries. We first divide OFDI destinations into two groups according to their level of development. The 12 destination countries are split into six developed and six developing countries based on the human development index (HDI) produced by UNDP.[30] In the data spanning from 2010 to 2019, approximately 38.6 percent of firms invested in developed countries, 61.4 percent in developing countries. Then, we use a dummy variable to add these terms in the regression: for column (B-1), 1 if OFDI is towards developed countries and 0 otherwise, and vice versa for column (B-2).

[29] The calculation is based on the coefficient from column (A-1) of Table 6 results.

[30] The human development index (HDI) measures human development at the country level regarding a long and healthy life, being knowledgeable, and having a decent standard of living. A country with a high HDI has a higher life expectancy, education level, and GNI per capita than other countries. According to this index, developed countries include the US, Italy, Japan, Germany, Singapore, and Hong Kong SAR, and developing countries include China, the State of Qatar, Indonesia, Vietnam, Brazil, and Mexico.

In column (B-1) for OFDI towards developed countries, the coefficient of the stand-alone *treat* variable is positive but not significant, whereas the coefficient for the interaction term between the OFDI destination dummy and *treat* is positive and statistically significant. This implies that positive and significant productivity spillovers effects are found for the parent company when OFDI is directed toward developed countries, but such positive effects do not exist when the destination is not specified. Developed countries typically have large markets as well as leading technology and know-how, which leads to a high possibility of transferring technology and knowledge to the parent company. To verify this finding, we calculate the average number of patents developed by affiliates in developed and developing countries, respectively. The results show that the number of patents in developed countries is 1.15 times higher than that in developing countries.[31] On the other hand, the results for OFDI towards developing countries in column (B-2) show that the coefficient of the interaction term is positive but insignificant. These results provide clear evidence that heterogeneous OFDI effects exist depending on the destination countries.

8. Measuring OFDI spillover effects on domestic firms

In addition to direct productivity effects on parent companies, OFDI can have indirect effects on the productivity of other domestic firms (1) in the same sector as the parent company (horizontal knowledge spillovers) or (2) in other sectors supplying inputs to the parent company (vertical knowledge spillovers). That is, OFDI can bring not only reverse knowledge spillovers to parent companies but also externalities that can increase the productivity of other domestic firms through industrial linkages. This is based on the argument that firms cannot fully internalize the potential benefits of OFDI because knowledge diffusion has the properties of public goods.

Transmission channels for horizontal spillovers depend on worker mobility and agglomeration effects, as argued in the literature on inward FDI. The former implies that domestic firms may absorb parent company's new technology and advanced managerial skills through the mobility of trained workers from the parent company to the domestic firms (Vahter & Masso, 2005). In addition, when new technology and products of parent companies are

[31] According to our dataset, the number of patents developed by Korean affiliates operating in developed (developing) countries is 9.98 (8.71).

introduced to home market, other domestic firms can observe and try to imitate them, thereby resulting in increased productivity (Halpern & Muraközy, 2007). At the same time, however, domestic companies in the same sector can become potential competitors, so the parent companies may have incentives to prevent knowledge leakages through intellectual property rights, trade secrets, and wage increases (Aitken & Harrison, 1999; Tang & Altshuler, 2014).

On the other hand, the parent companies may prefer to disseminate their knowledge to domestic firms supplying intermediate inputs (vertical spillovers), as they have complementary relationships with domestic suppliers in the production of the final goods. In order to use technically advanced inputs, parent companies provide direct assistance and train their domestic suppliers to produce and deliver inputs in a more efficient manner (Javorcik, 2004). Therefore, some literature supports empirical evidence in favor of positive vertical spillover effects rather than horizontal spillovers (Blalock & Gertler, 2008; Javorcik, 2004; Han & Kim, 2021).

8.1 Estimation model

In order to estimate OFDI spillovers, we construct proxy variables following Javorcik (2004). $Horizontal_{jt}$ captures the proportion of output produced by OFDI companies over total production in industry *j* at year *t*. For industry classification, we use the two-digit industry classification provided by KOSIS. In other words,

$$Horizontal_{jt} = \frac{\sum_{i \in j} Y_{ijt}^{OFDI}}{\sum_{i \in j} Y_{ijt}}$$

where $i \in j$ indicates a firm in a given industry j, Y_{ijt}^{OFDI} stands for the real output of OFDI firm *i* operating in industry *j* at year *t*, and Y_{ijt} presents the real output of general firm *i* in industry *j* at year *t*. Thus, $Horizontal_{jt}$ increases when OFDI firms produce more output in industry j.

A proxy for capturing vertical spillovers, $Vertical_{jt}$ indicates the presence of parent companies in the downstream sectors that are supplied by domestic firms in upstream sector j at year *t*. It measures the magnitude of knowledge spillovers from parent companies (consumers) to domestic firms (suppliers) and is defined as:

$$Vertical_{jt} = \sum_{j \neq n} \sigma_{jnt} Horizontal_{jt}$$

where σ_{jnt} is the proportion of sector j's output supplied to sector n taken from annual input-output matrix at the two-digit industry level.[32] Since $Horizontal_{jt}$ already captures the intra-industry spillover effects, we exclude the inputs supplied within the sector. As the interaction between parent companies and domestic suppliers increases, the value of $Vertical_{jt}$ increases.

We use the following model to estimate the effects of OFDI firms' presence on the productivity of other domestic firms, similar to Aitken and Harrison (1999) and Javorcik (2004).

$$TFP_{ijt} = \beta_0 + \beta_1 Horizontal_{jt} + \beta_2 Vertical_{jt} + \delta_t + \alpha_j + \theta_r + \varepsilon_{ijt} \quad (3)$$

where subscript i stands for firm, j for sector, r for region, and t for year, and ε_{ijt} indicates the idiosyncratic error term. In order to remove any unobservable variations, we include fixed effects for year (δ_t), industry (α_j), and region (θ_r).[33]

We include only domestic firms who were not engaged in OFDI in the sample to eliminate the possibility that productivity gains of other OFDI firms may have driven spillover effects of OFDI. $Horizontal_{jt}$ captures the intra-industry spillovers, and $Vertical_{jt}$ measures the inter-industry spillovers to domestic firms in the sector j at year t. Since the proxies for capturing OFDI spillovers are measured at the industry level, the clustered standard error for the industry-year combination is applied to correct the potential correlation between observations belonging to the same industry each year. Finally, we also run separate regressions using contemporary and lagged explanatory variables (up to 2 years) considering that it may take time for the knowledge diffusion from the parent company to materialize.

8.2 Estimation results

[32] This measure excludes the amount supplied to imported products and the final consumption to capture the actual vertical spillover effects in the home market.

[33] Year dummies (δ_t) control for economy-wide shocks, industry dummies (α_j) control for industry-specific productivity trends, and 12 regional fixed effects (θ_r) control for regional productivity trends such as improvements in infrastructure (Javorck, 2004). The regional dummies (θ_r) are the same as described in equation (2).

Table 7 shows the estimation results of the empirical model (3). The coefficients of $Horizontal_{jt}$, which capture intra-industry spillovers, are negative and statistically significant for contemporaneous and one-year lagged cases. The existence of OFDI firms reduces the productivity of other domestic firms in the same industry. This result is consistent with previous studies that have found negative horizontal spillover effects from OFDI (Aldaba & Aldaba, 2013; Tang & Altshuler, 2014; Vahter & Masso, 2005). Competition within the industry may have deterred worker mobility and agglomeration effects, which harms the productivity of other domestic firms. These negative effects become weaker in lagged terms, suggesting that other domestic firms may have mitigated negative horizontal spillover effects over time.

[Insert Table 7 here]

In contrast, $Vertical_{jt}$, which captures inter-industry spillovers, shows significant and positive coefficients across all specifications. This result suggests that reverse knowledge spillovers from OFDI flow into domestic suppliers in other sectors. That is, OFDI boosts the productivity of domestic suppliers by transferring knowledge and technology. Note that the coefficient becomes larger for lagged variables, implying that the externality of knowledge generated in the consumer-supplier relationship becomes stronger over time. Economically, a one-standard-deviation increase in OFDI firms in the downstream sector is associated with a 6.4% percent increase in TFP of domestic suppliers in the upstream sector two years later.[34]

9. Conclusion

This study examines the impacts of OFDI on the productivity of parent companies in the manufacturing and service sectors in South Korea over the period from 2010 to 2019. Our contribution is that we estimate the OFDI effects by constructing a micro firm-level database containing detailed OFDI activities along with comprehensive information on Korean companies. Combining PSM and DID approaches, we find strong evidence that OFDI promotes the productivity of parent companies, implying that foreign affiliates can be seen as vehicles to transfer the acquired strategic assets back to their parent companies.

[34] The standard deviations of the two-year lagged vertical and TFP1 variables in column (A-3) are 0.175 and 1.522, respectively. The coefficient of the two-year lagged vertical is 0.558. Thus, the final result is calculated as (0.175/1.522)*0.558 = 0.064.

Firms have different motives for OFDI, which determine the nature of OFDI and lead to heterogeneous reverse knowledge spillover effects. Thus, we consider a series of underlying factors in empirical analysis that may account for the heterogeneous reverse knowledge spillovers. We found that positive OFDI effects become greater when OFDI is in the M&A form and towards developed countries because the motives for OFDI in M&A form and towards developed countries are aimed at pursuing efficiency and strategic assets rather than natural resources or market expansion. We also show that the absorptive capacity of parent companies generated by greater learning capabilities and in-house R&D activities plays an important role in amplifying positive spillover effects. Besides these direct effects, we also find strong evidence that OFDI brings positive spillover effects to domestic firms in other sectors (vertical spillovers).

In 2013, the Korean government enacted a 'U-turn policy,' which offers tax benefits, land, and subsidies to encourage companies to allocate their foreign investment back to Korea. Under the Trump administration, the US implemented notorious interventions to promote foreign capital investment in the US. Policymakers allege that OFDI is responsible for reducing employment, domestic investment, and export. However, this study confirms that some OFDI brings positive reverse knowledge spillovers not only to parent companies but also to other domestic suppliers in supply chains.

Our findings provide several policy implications for increasing positive productivity spillovers from OFDI. For example, OFDI in the form of M&A and towards developed countries should be promoted to achieve positive productivity effects. Furthermore, providing financial incentives, such as grants and loans for in-house R&D activities, is encouraged to maximize the positive reverse spillover effects since firms' absorptive capacity plays important role in materializing spillover effects. Investment incentives should be selective and discriminatory according to the natures of OFDI and the parent company.

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Table 1. Descriptive statistics of OFDI and domestic firms

	Panel A Whole Sample		Panel B PSM treated sample	
	Domestic Firms	OFDI Firms	Domestic Firms	OFDI Firms
TFP1	3.66	3.77	3.26	3.36
TFP2	0.98	1.03	0.94	1.01
Firm Size	4.67	5.33	5.24	5.24
Capital Intensity	5.60	6.19	6.01	5.97
R&D Intensity	5.86	6.98	6.16	6.65
Export Intensity	0.07	0.20	0.12	0.15
Labor Intensity	5.66	6.08	5.96	6.01
Outsourcing R&D	0.19	1.67	0.52	1.15
# of Patents by affiliates	1.59	2.47	1.85	2.00
Intra-firm Gross Sale	3.61	5.09	3.84	4.05
Intra-firm Exports	2.19	4.78	0.91	3.58
Intra-firm Imports	1.80	4.39	2.25	2.80
HHI	20.99	37.63	1.88	1.86

Notes: TFP1 = log TFP estimated by the Levinsohn-Petrin approach, TFP2 = log TFP estimated by OLS estimation, Firm Size = log(# of employees), Capital Intensity= log(total assets/ # of employees), R&D Intensity = log(R&D expenses), Export Intensity = log(direct exports/gross sales), Labor Intensity = log(gross sales/# of employees), HHI(Herfindahl–Hirschman index) = log($\sum_{j=1}^{i} Marketshares_i^2$). All nominal variables are converted to real variables using appropriate indices.

Table 2. *t*-test results

	Original Sample before matching			Treated sample with PSM		
	OFDI firms	Domestic firms	Paired t-statistics	OFDI firms	Domestic firms	Paired t-statistics
TFP1	3.77	3.66	7.49***	3.36	3.26	1.48
Firm Size	5.33	4.67	77.92***	5.24	5.24	-0.02
Intermediate Input	10.55	9.15	85.88***	10.45	10.60	-0.60
Capital Intensity	6.19	5.60	67.32***	5.97	6.01	-0.35
R&D Intensity	6.98	5.86	59.87***	6.65	6.16	2.20**
HHI	37.63	20.99	41.92***	1.86	1.88	-0.30
N	23,476	35,319		450	450	
Pseudo R^2	0.13			0.03		
LR chi2	39.44**			3.76		

Notes: (1) ***, **, * denote statistical significance level at the 1%, 5%, 10%, respectively. (2) The paired *t*-test evaluates the equality of the means before and after matching. (3) The Pseudo R^2 evaluates the goodness-of-fit of the logit model. (4) LR chi^2 indicates the likelihood ratio chi-square test, which tests the hypothesis that all coefficients (other than the constant) are equal to zero.

Table 3. Benchmark estimation results

	Dependent variable				Base year		
	TFP1 (A-1)	TFP2 (A-2)	Gross sale (A-3)	Patents (A-4)	TFP1 in 2014	TFP1 in 2015	TFP1 in 2016
Self	4.920*** (0.20)	0.847*** (0.18)	10.01*** (0.35)	1.840*** (0.67)	4.773*** (0.27)	3.762*** (0.19)	3.875*** (0.24)
Treat	0.091*** (0.03)	0.067*** (0.02)	0.209*** (0.05)	0.315*** (0.09)	0.073*** (0.03)	0.074** (0.03)	0.125** (0.06)
Time	4.885*** (0.21)	0.782*** (0.18)	9.991*** (0.35)	2.166*** (0.67)	4.727*** (0.27)	3.707*** (0.19)	3.785*** (0.24)
Adj. R-squared	0.98	0.98	0.99	0.94	0.99	0.99	0.99
N	900	900	900	900	620	200	180

Notes: (1) ***, **, * denotes statistical significance level at the 1%, 5%, 10%, respectively. (2) Standard errors are reported in parentheses. (3) Refer to Table 2 for the definitions of TFP1 and TFP2. (4) We use log of real gross sales and number of patents as dependent variable in Panels (A-3) and (A-4), respectively. (5) Firm, industry, and regional dummies are included.

Table 4. Estimation results based on parent company's characteristics

	Panel A: Industry		Panel B: Factor Intensity				Panel C: Technology level		
	Manufacturing	Service	R&D intensity	Capital Intensity	Export Intensity	Labor Intensity	High-tech	Medium-tech	Low-tech
TFP1	3.248	4.432	4.170	2.563	3.993	2.073	4.442	4.404	3.177
Self	4.920*** (0.20)	5.219*** (0.10)	4.827*** (0.25)	4.988*** (0.11)	3.734*** (0.15)	3.12*** (0.29)	5.756*** (0.27)	3.663*** (0.18)	4.177*** (0.17)
Treat	0.073*** (0.03)	0.269*** (0.09)	0.090** (0.04)	0.026 (0.03)	0.072 (0.05)	0.034 (0.04)	0.105** (0.05)	0.066* (0.04)	0.065 (0.04)
Time	4.900*** (0.20)	5.015*** (0.08)	4.811*** (0.24)	4.960*** (0.12)	3.680*** (0.15)	3.234*** (0.30)	5.725*** (0.27)	3.646*** (0.18)	4.133*** (0.18)
Adj. R-squared	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
N	850	50	431	299	376	331	373	368	179

Notes: (1) ***, **, * denotes statistical significance level at the 1%, 5%, 10%, respectively. (2) Standard errors are reported in parentheses. (3) TFP1 indicates the level of TFPs of each sub-sample. (4) Firm, industry, and regional dummies are included.

Table 5. Role of absorptive capacity of parent company

	Panel A (Proxy 1)		Panel B (Proxy 2)		Panel C (proxy 3)	
	TFP1 (A-1)	TFP2 (A-2)	TFP1 (B-1)	TFP2 (B-2)	TFP1 (C-1)	TFP2 (C-2)
Self	4.602*** (0.21)	0.788*** (0.24)	3.735*** (0.23)	0.023 (0.19)	3.747*** (0.20)	-0.051 (0.17)
Treat	-0.018 (0.06)	-0.059 (0.06)	0.089*** (0.03)	0.069*** (0.02)	0.088*** (0.03)	0.068*** (0.02)
Factor	0.064* (0.03)	-0.054 (0.04)	-0.105** (0.05)	-0.037 (0.04)	-0.369* (0.15)	-0.172 (0.13)
Treat x Factor	0.118* (0.06)	0.061 (0.07)	0.109*** (0.03)	0.133*** (0.02)	0.328*** (0.08)	0.428*** (0.07)
Time	4.033*** (0.21)	0.836*** (0.24)	3.707*** (0.23)	-0.040 (0.19)	3.718*** (0.21)	-0.114 (0.17)
Adj.R-squared	0.99	0.88	0.99	0.73	0.99	0.73
N	810	810	900	900	900	900

Notes: (1) ***, **, * denotes statistical significance level at the 1%, 5%, 10%, respectively. (2) Standard errors are reported in parentheses. (3) *Self* captures the self-selection effect, *Treat* shows the productivity effect from OFDI, *Factor* indicates the absorptive capacity, and the (Treat x Factor) captures the degree of OFDI effect added by the absorptive capacity of parent companies. *Time* controls the time effect after OFDI. (4) Firm, industry and regional dummies are included. (5) The Panel A adopts the lag of TFP in the measurement of absorptive capacity, so number of observations (N) decreased from 900 to 810.

Table 6. Role of OFDI characteristics

	Panel A: Entry Mode		Panel B: Destination Countries	
	M&A (A-1)	Greenfield (A-2)	Developed (B-1)	Developing (B-2)
Self	0.0387 (0.02)	0.0387 (0.02)	4.330*** (0.13)	4.262*** (0.13)
Treat	0.065** (0.03)	0.147*** (0.04)	0.021 (0.06)	-0.047 (0.06)
Factor	1.813*** (0.16)	-0.312*** (0.16)	-0.361*** (0.104)	-0.062 (0.09)
Treat x Factor	0.082** (0.02)	-0.082** (0.04)	0.257** (0.12)	0.116 (0.11)
Time	0.006 (0.02)	0.006 (0.02)	4.387*** (0.13)	4.357 (0.13)
Adj. R-squared	0.99	0.99	0.99	0.99
N	900	900	900	900

Notes: (1) ***, **, * denotes statistical significance level at the 1%, 5%, 10%, respectively. (2) Standard errors are reported in parentheses. (3) TFP1 is used for all estimation. (4) In Panel B, developed countries include the US, Italy, Japan, Germany, Singapore, and Hong Kong SAR, and developing countries include China, State of Qatar, Indonesia, Vietnam, Brazil, and Mexico. (5) Firm, industry, and regional dummies are included.

Table 7. OFDI productivity spillovers to domestic firms

	Dependent variable: TFP1		
	Contemporaneous	One year lagged	Two years lagged
Horizontal	-0.853*** (0.27)	-0.513** (0.25)	-0.282 (0.28)
Vertical	0.477*** (0.11)	0.488** (0.22)	0.558* (0.32)
Adj. R-squared	0.93	0.91	0.87
N	450	405	360

Notes: (1) ***, **, * denotes statistical significance level at 1%, 5%, 10%, respectively. (2) Standard errors are reported in parentheses. (3) We use the firm-level TFP measured by the Levinson-Petrin approach as a dependent variable (TFP1), and adopt the contemporaneous, one-, and two-year lagged explanatory variables for all regressions. (4) *Horizontal* measures intra-industry OFDI spillovers, and *Vertical* captures inter-industry spillovers. (5) Year, industry, and regional dummies are included.

Figure 1. General trend of OFDI in Korea during 1990-2020

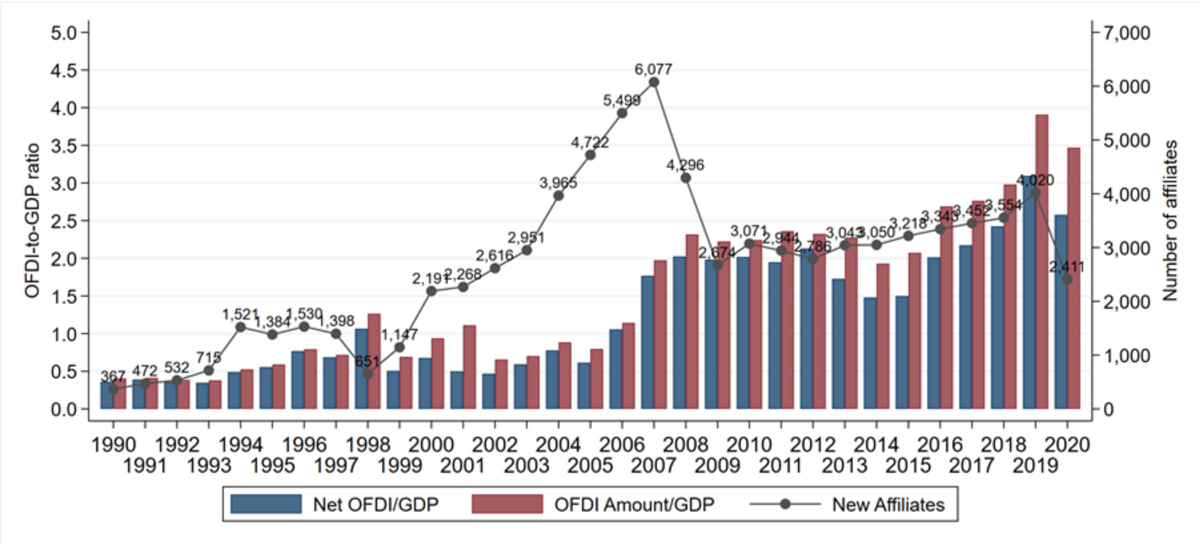

Figure 2. Industry-specific trend of OFDI in Korea during 1990-2020

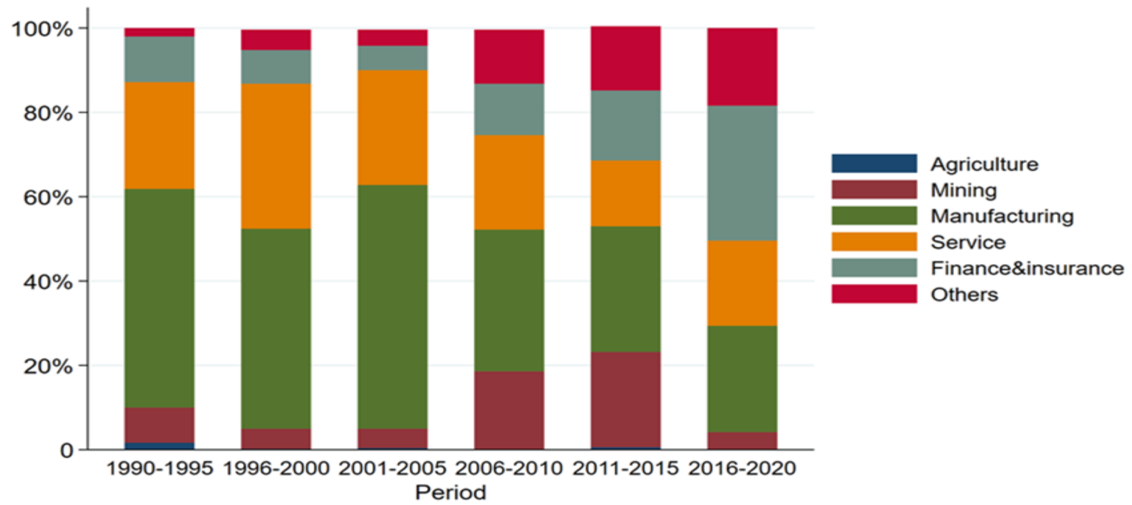

Figure 3. Kernel density distribution before and after PSM