Journal of Korea Trade Vol. 26, No. 3, May 2022, 102-116
https://doi.org/10.35611/jkt.2022.26.3.102
ISSN 1229-828X

JKT 26(3)

Received 15 March 2022
Revised 10 April 2022
Accepted 6 May 2022

Importing and Firm Productivity: Evidence from Korean Manufacturing Firms*

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Abstract

Purpose – This paper empirically investigates the relationship between firm productivity and importing intermediate inputs in the Korean manufacturing sector.
Design/methodology – This paper tests the two related hypotheses on the relationship between importing and productivity for a sample of Korean manufacturing firms. We test the self-selection hypothesis by comparing pre-entry levels of productivity between importers and non-importers. We test the learning-by-importing hypothesis by employing propensity score matching with difference-in-differences approach.
Findings – Future importers are more productive than future non-importers years before they start to import, which supports the self-selection hypothesis. In contrast, there is no strong evidence for learning-by-importing.
Originality/value – This paper is the first study to explore the relationship between importing and firm-level productivity for Korean firms. The results have an important implication on trade policies to lower or raise trade barriers in imported inputs.

Keywords: Intermediate Goods, Import, Productivity
JEL Classifications: D24, F14, F23

1. Introduction

Modern international trade has been greatly shaped by global supply chains and fragmentation of production. Production is organized into several stages and divided among different firms that are often located in different countries. This implies firms become more dependent on foreign suppliers. Recent decades witness a rapid rise in trade in intermediate goods across the world (Hummels et al., 2001; Hanson et al., 2005; Johnson and Noguera, 2012). Intermediate goods account for 56% of total trade in goods among OECD countries (Miroudot et al., 2009), and the number is even higher for Korea reaching 70% (Kim Young-Gui and Pyo Hak-Kil, 2016; Jang Yong-Joon and Cho Mee-Jin, 2015; Kim Kyung-Min, 2020).

Reliable supply of intermediate goods is an important factor for the international competitiveness of a firm or a country (Beltramello et al., 2012).[1] Firms can source inputs from foreign suppliers at lower prices or make use of inputs that are not locally available (Elliott et al., 2016). More importantly, firms may have access to new technology and knowledge through the use of imported intermediate goods (Grossman and Helpman, 1991).

This paper uses Korean manufacturing data to explore the interaction between importing and productivity at the firm level. In doing so, we try to answer the following two questions. First, which type of firms are more likely to start importing? Second, how do firm perfor-

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mance evolve after starting to import? Specifically, we focus on firm-level productivity when answering the questions. International trade theory suggests that there may exist bi-directional causal relationship between importing and firm productivity. The so-called self-selection hypothesis suggests that more productive firms choose to import while less productive firms choose to source only locally. On the other hand, the learning-by-importing hypothesis predicts that firms improve in productivity after starting to import. It is an empirical question to determine whether these hypotheses are valid or which of the two is more important.

The relationship between importing and productivity have important implications for policy areas. Trade policy has different consequences according to relative importance of self-selection and learning. If learning-by-importing dominates the self-selection effect, import-inducing policy will significantly improve overall productivity of an economy; however, if self-selection is more important than learning-by-importing, then import-inducing policy is unlikely to have a significant effect on productivity.

This paper adds a new case study to the fast-growing literature on the relationship between importing and firm productivity. Evidence in the extant literature suggests that learning-by-importing is significant mostly among firms in less-developed countries; however, studies on advanced economies are limited and they provide mixed results. To the best of our knowledge, this paper is the first attempt to study importing and productivity at the firm level using Korean data.[2]

The main findings of this paper can be summarized as follows. First, importers have superior productivity over non-importers. A typical importer is more productive by 6-10 percentage points than a similar-sized non-importer in the same industry. Second, importers were found to be already more productive than non-importers even before they start to import. Specifically, the total factor productivity of importers was 7-8 percentage point higher than that of non-importers three years before their entry into importing. This implies that higher productivity leads to importing, providing evidence for the self-selection hypothesis. Finally, we find no evidence supporting the learning-by-importing hypothesis. Firms do not show significant improvement in productivity after they begin to import. The results do not change when we employ different definitions of an importer or different sub-samples. Overall, the productivity differential between importers and non-importers can be explained mostly by self-selection rather than by learning-by-importing.

This paper proceeds as follows. We review the existing literature in section 2 and introduce data in section 3. In section 4, we describe basic patterns of importers' productivity. In section 5, we test the presence of self-selection and learning-by-importing. And section 6 concludes.

2. Literature

As micro data sets become increasingly more available, the attention of research in international trade has shifted from countries and industries toward firms. A line of empirical

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[1] In both academic research and policy discussions, export is acclaimed as a driver of economic growth, whereas less attention is given to positive effects of import on productivity growth. Economic analysis of import liberalization is mostly concerned with import competition in the final goods market.

[2] Although increasingly more papers use firm-level micro data to study the internationalization of Korean firms, they mostly explore exporting and foreign direct investment.

research, pioneered by Aw and Hwang (1995) and Bernard and Jensen (1995), has established a series of stylized facts about exporting firms: for example, exporters are larger in size, more productive, and more capital-intensive than non-exporters.[3]

Although early literature largely focuses on exporting while neglecting importing, a growing number of papers start to explore the characteristics of typical importers. This new literature finds that importers have features that are similar to those of exporters: importers are also more productive than non-importers. The productivity premium of importers has been reconfirmed in many countries: among these are Belgium (Muûls and Pisu, 2009), Chile (Kasahara and Rodrigue, 2008), China (Elliott et al., 2016; Zhou et al., 2020), Germany (Vogel and Wagner, 2010), Hungary (Halpern et al., 2015), Ireland (Forlani, 2017), Italy (Castellani et al., 2010), Poland (Hagemejer and Kolasa, 2011), Spain (Augier et al., 2013), Sweden (Andersson et al., 2008), and the US (Bernard et al., 2018).

This empirical regularity is often explained by two related hypotheses. The self-selection hypothesis argues that superior productivity leads to importing whereas the learning-by-importing hypothesis suggests that importing leads to superior productivity. The two explanations are not mutually exclusive but it is of interest which of the two is more relevant.

The self-selection hypothesis is based on the argument that firms must incur fixed costs before starting to import. The fixed costs are associated with searching for potential foreign suppliers, negotiating contract terms, dealing with complex customs procedures, etc (Castellani et al., 2010; Andersson et al., 2008). Kasahara and Lapham (2013) extends Melitz (2003) and presents a theoretical model involving fixed costs of importing. The model predicts that only highly productive firms can afford to incur these costs and to profit from importing. Furthermore, Antras et al. (2017) proposes a model in which importers incur fixed costs for each country from which they import. Their model predicts that more productive firms import from more countries.

Empirical evidence largely supports the self-selection hypothesis. The standard method to test the self-selection hypothesis is to check whether importers have superior productivity over non-importers even before starting to import. Vogel and Wagner (2010) investigates German manufacturers in 2000s and finds that importers were more productive than non-importers three years before starting to import. Castellani et al. (2010) uses detailed panel data of Italian firms in 1990s to study the relationship between international trade activities and productivity. According to their studies, future importers are already larger, more productive, and more capital-intensive than future non-exporters. Elliott et al. (2016) analyzes a panel data set of Chinese manufacturers to explore two-way causal relationship between importing and productivity. They estimate a probit model describing a firm's decision to enter the importing market. They find that lagged productivity significantly raises the probability of importing while controlling for firm characteristics such as size, ownership, wage, etc.

The learning-by-importing hypothesis represents an alternative view on the relationship between importing and productivity. Firms can benefit from importing because foreign suppliers can be price competitive or they can provide inputs that are not locally available. Furthermore, firms may learn new technology and knowledge embodied in imported inputs. Markusen (1989) suggests that trade in intermediate goods improves productivity as domestic inputs and foreign inputs are often complementary. Grossman and Helpman

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[3] See Bernard et al. (2012/2018) and Wagner (2012/2016) for surveys of the related literature. The stylized facts about exporters become a key element in subsequent theoretical models such as Melitz (2003) and Bernard (2003).

(1991) argues that R&D activities in one country have positive externalities on productivity in trading partner countries.

Empirical research provides mixed evidence on the learning-by-importing hypothesis. The literature finds relatively stronger evidence in less-developed economies than in advanced economies. Elliott et al. (2016) shows that Chinese manufacturers improve in productivity after starting to import and the effect is stronger when firms import from developed countries or when they import a greater variety of inputs. Significant learning-by-importing is found in other countries, such as Chile (Kasahara and Rodrigue, 2008), Ethiopia (Abreha, 2019), and South Africa (Edwards et al., 2020). A small, related literature investigates import tariffs rather than the decision to import.[4] Amiti and Konings (2007) shows the reduction in input tariffs has a significant effect on the productivity of Indonesian firms. Goldberg et al. (2010) uses firm-level data from India and finds that lower tariffs induce firms to introduce new products.

Evidence of learning-by-importing in advanced economies does not seem as clear as in developing economies. Forlani (2017) shows that the intensive margin of imports affects positively the productivity of Irish firms. According to Augier et al. (2013) which analyzes a panel of Spanish firms, the effect of the decision to import on productivity is not significant on average but strong among firms with a high proportion of skilled labor. Vogel and Wagner (2010) finds no evidence of learning-by-importing for German manufacturers in early 2000s.

No existing papers explore the relationship between importing and firm-level productivity using Korean data.[5] But there are a few papers that explore the exporting side of international trade and investigate exporting and firm productivity. Chun Hyun-Bae et al. (2012) reports a significant difference in productivity between exporters and non-exporters. Aw et al. (2000), Hahn Chin-Hee and Park Chang-Gyun (2004), and Lee Si-Wook and Choi Yong-Seok (2009) present evidence for learning-by-exporting in the Korean manufacturing sector.

3. Data

This paper uses the Survey of Business Activities (SBA) published by Statistics Korea. The SBA is a longitudinal survey of all Korean firms employing 50 workers or more. This data set contains various firm characteristics as well as export and import amount, which makes this data set suitable for studying international trade activities at the firm level. This paper uses only five waves of the SBA from 2010 to 2014. We exclude early waves up to 2009 to avoid any possible confounding effects of the 2008 financial crisis. We also exclude recent waves from 2015 because the SBA has changed its definitions of export and import, making it difficult to use the series continuously. Furthermore, in order to track firm productivity over time, we only include firms that are present in the data set for all five years. The final sample is a balanced panel of 3,068 firms over five years, consisting of 15,340 firm-year pairs.

Table 1 presents the share of importers in terms of the number of firms, value-added, and workers. Importers account for 46.5% of the sample in 2010 and 49.7% in 2014. Importers'

[4] Output tariffs affect firm performance through different channels than input tariffs. Lowering import tariffs on final outputs intensifies competition in the output market and reallocates resources from less efficient firms to more efficient ones, and thus raising the overall productivity (Trefler, 2004; Pavcnik, 2002).

[5] There are a couple of industry-level studies including Jang Yong-Joon and Cho Mee-Jin (2015) and Kim Young-Gui and Pyo Hak-Kil (2016). They explore the effects of import in intermediate inputs on the aggregate productivity rather than on the firm-level productivity.

share in value-added is around 80% and the share in workers is around 70%, much higher than importers' share in the number of firms. This is because importers are larger in size than non-importers.

Table 1. Share of Importers

	2010	2011	2012	2013	2014
Firms					
Non-importers	1642	1609	1616	1576	1544
Importers	1426	1459	1452	1492	1524
Share of importers (%)	46.5	47.6	47.3	48.6	49.7
Value-added (trillion won)					
Non-importers	31.2	35.2	38.8	31.6	33.4
Importers	137	130	136	161	160
Share of importers (%)	81.5	78.7	77.8	83.6	82.7
Workers (thousand persons)					
Non-importers	323.9	336.9	380.7	321.9	341.1
Importers	826.8	865.1	842.5	938.8	939.5
Share of importers (%)	71.9	72	68.9	74.5	73.4

4. Productivity Comparison

this section, we make a cross-sectional comparison of productivity between importers and non-importers. We measure the total factor productivity (TFP) of a firm following the chained-multilateral index number approach developed by Good (1985) and Good et al. (1999). The index number approach has the advantage of being robust to alternative assumptions on production technologies, measurement errors, and input prices.[6] Furthermore, the chained-multilateral index number method has been repeatedly used in studying the productivity of Korean firms, which facilitates comparison across different studies (Hahn Chin-Hee and Park Chang-Gyun, 2010; Lee Si-Wook and Choi Yong-Seok, 2009; Ahn Sang-Hoon, 2005). This approach sets a reference firm for each cross-section and chain-links the reference firms over time. This allows us to measure the productivity of a firm relative to a reference firm in the first period and to make transitive comparison among firms in the panel data.

Specifically, the TFP index is measured as follows.

$$\begin{aligned}\ln TFP_{it} &= \left(\ln Y_{it} - \overline{\ln Y_t}\right) + \textstyle\sum_{\tau=2}^{t}\left(\overline{\ln Y_\tau} - \overline{\ln Y_{\tau-1}}\right)\\ &\quad - \left\{\tfrac{1}{2}\left(s_{Lit} + \overline{s_{Lt}}\right)\left(\ln L_{it} - \overline{\ln L_t}\right) + \textstyle\sum_{\tau=2}^{t}\tfrac{1}{2}\left(\overline{s_{L\tau}} + \overline{s_{L\tau-1}}\right)\left(\overline{\ln L_\tau} - \overline{\ln L_{\tau-1}}\right)\right\}\\ &\quad - \left\{\tfrac{1}{2}\left(s_{Kit} + \overline{s_{Kt}}\right)\left(\ln K_{it} - \overline{\ln K_t}\right) + \textstyle\sum_{\tau=2}^{t}\tfrac{1}{2}\left(\overline{s_{K\tau}} + \overline{s_{K\tau-1}}\right)\left(\overline{\ln K_\tau} - \overline{\ln K_{\tau-1}}\right)\right\} \qquad (1)\end{aligned}$$

[6] See Van Bieserbroeck (2007) for various methods of estimating productivity and their strengths and weaknesses.

where Y is the real value-added, L is the number of workers, and K is capital measured by the real value of tangible fixed assets. s_L and s_K are the expenditure shares of labor and capital. Subscript i represents firms and subscripts t and τ represent years. The upper bar denotes the average of a variable and also denotes the characteristics of a reference firm for each cross-section. Thus, reference firms are a hypothetical firm with average input shares and average input levels.

The first task in empirical analysis is to test whether importers have superior productivity over non-importers. In the first two columns of Table 2, we report productivity indices for importers and non-importers. Column (3) shows the difference in productivity between the two groups and t-test results. In all years, importers are more productive than non-importers by 7-12 percentage points and all differences are statistically significant at the 1% level. The adjusted difference in column (4) means the difference in productivity after controlling for firm size and industries. If industry composition is considerably different between importers and non-importers and the average productivity levels are different among industries, then unadjusted differences may reflect not only import status but industry composition. In order to address this issue, we regress lnTFP on an importer dummy, the log of the number of workers, and industry dummies. Then, the coefficient on the importer dummy represents the productivity difference after controlling for firm size and industries. Adjusted differences are smaller than unadjusted differences but they all are statistically significant at 1%. This cross-sectional pattern, however, is mere correlation and should not be interpreted to represent any causal relationship. In the next section, we attempt to uncover two-way causality between importing and productivity.

Table 2. Comparison of Productivity: Importers and Non-importers

	(1) Importers	(2) Non-importers	(3) Difference (1) - (2)	(4) Adjusted difference
2010	0.064	-0.051	0.115*** (0.017)	0.101*** (0.018)
2011	0.036	-0.066	0.101*** (0.016)	0.097*** (0.017)
2012	0.025	-0.054	0.080*** (0.016)	0.082*** (0.017)
2013	0.046	-0.024	0.069*** (0.016)	0.061*** (0.017)
2014	0.066	-0.038	0.104*** (0.016)	0.081*** (0.017)

Note: Column 4 displays coefficient estimates on an importer dummy from regressing lnTFP on an importer dummy, the log of the number of workers, and industry dummies. Standard errors are in parentheses. ***, **, and * represents statistical significance at 1%, 5%, and 10% respectively.

5. Self-selection and Learning-by-importing

The literature typically employs the following methods to test the self-selection hypothesis. First, t-tests or regressions are used to test whether future importers were more productive than future non-importers even before importers start to import. If productivity premium precedes the decision to import, it implies more productive firms chooses to import. Second, a more direct approach is to approximate a firm's choice to start importing by estimating a binary choice model and to include lagged productivity as an independent variable. We report the result from the first approach here, and show the result from the second approach later along with the test for learning-by-importing.

In Table 3, we compare productivity between future importers and future non-importers. To take an example, in the first row of Panel A, we compare 2010 productivity between firms that start to import in 2011 and firms that do not. Similarly, in the first row of Panel B, we compare 2010 productivity between firms that start to import in 2012 and firms that do not. We also report both unadjusted and adjusted differences.

All unadjusted differences are positive and they are statistically significant except one case. Adjusted differences become slightly smaller than unadjusted differences, and most of them are significantly positive. Estimated differences in productivity mostly range 5-10 percentage points. The conclusion from Table 3 is clear: importers were more productive than non-importers years before they start to import. This is consistent with the self-selection hypothesis.

Table 3. Comparison of Productivity: Future Importers and Future Non-importers

	(1) Future Importers	(2) Future Non-importers	(3) Difference (1) - (2)	(4) Adjusted difference
		A. One year before starting to import		
2010	0.068	-0.086	0.155*** (0.026)	0.148*** (0.027)
2011	-0.030	-0.074	0.044 (0.027)	0.034 (0.027)
2012	0.003	-0.066	0.069** (0.029)	0.064** (0.029)
2013	0.045	-0.040	0.085*** (0.028)	0.086*** (0.028)
		B. Two years before starting to import		
2010	0.011	-0.074	0.085*** (0.025)	0.073*** (0.026)
2011	-0.029	-0.078	0.050** (0.025)	0.036 (0.025)
2012	0.002	-0.073	0.076*** (0.025)	0.075*** (0.025)
		C. Three years before starting to import		
2010	-0.004	-0.071	0.067*** (0.025)	0.054** (0.025)
2011	-0.007	-0.090	0.082*** (0.024)	0.072*** (0.024)
		D. Four years before starting to import		
2010	0.020	-0.086	0.106*** (0.024)	0.096*** (0.025)

Note: Column 4 displays coefficient estimates on an importer dummy from regressing lnTFP on an importer dummy, the log of the number of workers, and industry dummies. Standard errors are in parentheses. ***, **, and * represents statistical significance at 1%, 5%, and 10% respectively.

Testing the learning-by-importing hypothesis is a bit more complex. The standard method in the literature is to combine propensity score matching with difference-in-differences approach. This combination is known to be the most reliable way of estimating treatment effects in the non-experimental setting (Blundell and Costa-Dias, 2000). Propensity score matching forms a matched set of treated and untreated subjects which share similar characteristics. In this paper, import starters are the treatment group and each firm in the treatment group is matched with a non-importer of similar characteristics. The matched non-importers serve as the control group and approximate counterfactual outcomes that would occur if import starters did not import.

Specifically, we use a probit model to estimate the propensity of a firm to enter the import market, that is, the dependent variable is a dummy variable that takes 1 if the firm is an import starter and 0 otherwise.[7] Independent variables include total factor productivity, firm size, the share of foreign ownership, average wage, exporter dummy, R&D expenditure to sales ratio, and industry dummies. All independent variables are lagged by one year in order to mitigate simultaneity.[8] We consult Elliott et al. (2016) and Augier et al. (2013) when choosing independent variables. It is worth noting that export status is included as an independent variable. Recent literature highlights that exporting and importing are complementary, facilitating each other (Bernard et al., 2018). This is because the same fixed cost is at least partially shared by both exporting and importing. Other variables are also commonly included in the empirical model. Productivity is a key variable explaining the selection effect. Foreign owned firms are often hypothesized to be more active in international trade. The interdependence between R&D and international trade has been well recognized in the literature (Neves et al., 2016).

The predicted probabilities from the probit model are called propensity scores. We match each import starter with a non-starter that has the closest value of propensity score.[9] Then, the average productivity effect among import starters, that is, the average treatment effect on the treated (ATT) is estimated using difference-in-differences approach as follows:

$$ATT_s = \frac{1}{N}\sum_{i=1}^{N}\{(\ln TFP_{i,s} - \ln TFP_{i,0}) - (\ln TFP_{j(i),s} - \ln TFP_{j(i),0})\} \qquad (2)$$

where N is the size of the treatment group, that is, the number of import starters. Subscript i is an index for import starters and subscript j(i) denotes a non-starter that is matched to firm i. Subscript s is a time index where 0 is the year immediately before a firm starts to import, 1 is the year in which a firm starts to import, and so on.

Learning-by-importing may occur gradually, and it is useful to track the effects over time. In order to follow the longest possible post-entry performance, we focus on a group of firms that start to import early in the sample period. In the following analysis, import starters are the firms that start to import in 2011 (firms that do not import in 2010 but import in 2011), and non-starters are the firms that are non-importers in both 2010 and 2011. This allows us to track the causal effects of importing over four years (2011-2014). This sub-sample includes 1,642 firms that are non-importers as of 2010, among which 374 firms start to import in 2011 and 1,268 firms remain to be a non-importer.

Table 4 summarizes explanatory variables of the probit model. Table 5 reports the probit estimation results. Column (1) displays coefficient estimates and column (2) the marginal effects evaluated at the average values of independent variables. A significantly positive coefficient on lnTFP suggests that, after controlling for other firm characteristics, more productive firms are more likely to start to import, which reconfirms the self-selection hypothesis. The marginal effect of lnTFP is estimated to be 0.071. To put this estimate in context, we compute the 25th percentile (-0.338) and the 75th percentile (0.169) of TFP in the sample. The difference in the probability to start importing between the two points is then 0.071 × (0.169 +

[7] Another possible model may use import status rather than starting to import. Then, the model asks whether firms that are possibly already importing start (or continue) to import in the next period. In contrast, this paper focuses on the decision of a firm to start importing.

[8] Although using lagged variables is a standard approach in the literature, the resulting model is not fully satisfactory as it ignores contemporaneous effects of independent variables. However, it is difficult to study contemporaneous roles of independent variables for lack of appropriate instruments.

[9] This method is called the nearest neighbor matching.

0.338) = 0.036, that is, a firm at the 75th percentile of TFP is more likely to start to import than a firm at the 25th percentile by 3.6 percentage points. Firm size, foreign ownership, and R&D intensity are also positively associated with the decision to import and statistically significant.

Table 4. Summary Statistics of Explanatory Variables

	mean	std. dev.	min	max
lnTFP	-0.051	0.455	-2.176	2.898
Firm size	4.866	0.673	2.639	10.392
Foreign ownership	0.052	0.199	0	1
Wage	44.424	19.533	3.950	303.205
Exporter dummy	0.468	0.499	0	1
R&D intensity	0.012	0.021	0	0.206

Table 5. Probit Estimation

	(1) Coefficients	(2) Marginal effects
lnTFP	0.246***	0.071***
	(0.092)	(0.026)
Firm size	0.279***	0.080***
	(0.053)	(0.015)
Foreign ownership	0.699***	0.202***
	(0.168)	(0.048)
Wage	0.004*	0.001*
	(0.002)	(0.001)
Exporter dummy	0.054	0.016
	(0.075)	(0.022)
R&D intensity	4.171**	1.203**
	(1.660)	(0.479)
Constant	-2.446***	
	(0.295)	
Log likelihood	-801.693	
Number of observations	1,642	

Note: The sample consists of 1,642 non-importers as of 2010. The dependent variable is a dummy variable indicating whether the firm starts to import in 2011. All independent variables are lagged by one year. Two-digit industry dummies are included in the model but their coefficients are not reported. Standard errors are in parentheses. ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively.

After obtaining the propensity scores, we proceed to estimate the probability effects of importing according to equation (2). By construction, the causal effects in equation (2) are interpreted as percentage differences in TFP. Table 6 displays the results. Each column represents the causal effects for the entry year (s = 1) and up to three years after starting to import (s = 2, 3, 4). The first row reports the baseline result. We find all estimated effects are statistically insignificant. And the magnitude of estimated effects is small compared to those from related studies. Elliott et al. (2016) in their study of Chinese manufacturers shows that the productivity effect exceeds 10 percentage points on the entry year and reaches 17-18 percentage points in the third year.

The previous literature reports mixed results on the learning-by-importing hypothesis (Wagner 2012). But it is worth noting that learning-by-importing is significant mostly among less-developed economies including China, Chile, Hungary, South Africa, Ethiopia, and India. It suggests firms in less-developed economies have greater potential to learn from imported intermediates. The insignificant evidence in Table 6 seems to be associated with the fact that the economy of Korea is relatively advanced.

Some import starters stop importing and some non-importers start importing. For those firms that often switch import status, it is less clear how to interpret the productivity effects over time. In the second row of Table 6, we exclude from the sample the firms that switch import status after 2011. Again, we find no significant evidence for learning-by-importing.

In the third and the fourth rows, we redefine a firm to be an importer only when its import exceeds a certain percentage of total spending on intermediates. Thus, firms that import only a little will no longer count as an importer. The threshold is set to be 10% in the third row and 20% in the fourth. Nonetheless, the results are not greatly different from the baseline. All estimates of the productivity effect are statistically insignificant.

Table 6. Effects of Importing on Productivity

	s=1	s=2	s=3	s=4	N
Baseline	-0.020	0.005	0.024	0.053	Treated: 374
	(0.027)	(0.033)	(0.035)	(0.041)	Untreated: 1268
W/o Switchers	-0.044	-0.005	0.001	0.016	Treated: 179
	(0.034)	(0.049)	(0.051)	(0.060)	Untreated: 874
Threshold = 10%	0.011	0.046	0.069	0.044	Treated: 245
	(0.032)	(0.042)	(0.044)	(0.055)	Untreated: 1397
Threshold = 20%	-0.004	0.017	0.011	0.035	Treated: 201
	(0.041)	(0.050)	(0.047)	(0.060)	Untreated: 1441

Note: In parentheses are the heteroskedasticity-consistent standard errors proposed by Abadie and Imbens (2006). ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively.

The above analysis shows the average effect on the treatment group but does not consider heterogeneity among firms. However, a few previous papers suggest that learning-by-importing may be pronounced for a specific group of firms. Zhou et al. (2020) and Damijan and Kostevc (2015) report that the learning effect is large among small-sized firms, and Augier et al. (2013) argues that the effect is significant only among R&D intensive firms. To test these predictions, we divide the sample according to firm size and R&D intensity, and estimate the productivity effects of importing for each group separately. We report the results in Table 7 and find no significant effects for any sub-sample or any time period. In the appendix, we report further sub-sample analysis. First, we divide the sample into five groups based on quintiles of firm size and R&D intensity, and estimate the effects of importing on productivity. Second, we estimate the productivity effects of importing for each industry group separately. As in the main analysis, we find no significant evidence supporting learning-by-importing.

To summarize our discussion on learning-by-importing, we find no evidence for the significant effects of importing on firm productivity. Import starters seem to experience productivity changes that is not significantly different from those of non-starters. This is in stark contrast to strong evidence found for the self-selection hypothesis. Overall, it can be said that the cross-sectional difference in productivity between importers and non-importers is explained mostly by the self-selection effect.

Table 7. Effects of Importing on Productivity: Sub-sample Analysis

	s=1	s=2	s=3	s=4	N
Firm size					
Bottom 50%	-0.023	0.005	-0.012	-0.076	Treated: 144
	(0.046)	(0.058)	(0.056)	(0.068)	Untreated: 679
Top 50%	-0.039	-0.008	0.026	0.045	Treated: 230
	(0.046)	(0.051)	(0.054)	(0.064)	Untreated: 589
R&D intensity					
Bottom 50%	0.019	0.032	0.051	0.054	Treated: 163
	(0.039)	(0.046)	(0.048)	(0.055)	Untreated: 658
Top 50%	0.004	0.034	0.004	0.035	Treated: 211
	(0.037)	(0.045)	(0.047)	(0.054)	Untreated: 610

Note: In parentheses are the heteroskedasticity-consistent standard errors proposed by Abadie and Imbens (2006). ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively.

6. Conclusion

This paper investigates the relationship between productivity and firms' decision to import intermediate inputs. First, we have established that importers are on average more productive than non-importers. Then, we proceed to explore the bi-directional causal relationship between importing and productivity. We find strong evidence for the self-selection hypothesis whereas there is no such evidence for the learning-by-importing hypothesis. To the best of our knowledge, this paper is the first to investigate the relationship between productivity and importing at the firm level for Korean firms.

Our analysis suggests that productivity differential between importers and non-importers is mostly due to the self-selection effect. This conclusion may have an important implication on trade policies to lower or raise trade barriers in imported inputs. Policy makers are generally well informed of the benefits of importing final goods. Import competition in the final goods market raises consumer welfare and facilitates resource reallocation among firms, which improves the overall efficiency of an economy. But the role of importing in intermediate goods is less clearly understood. According to our analysis, tariff reduction in imported inputs is unlikely to have significant impacts on the productivity of firms that import intermediate goods.

Finally, we discuss limitations of this paper. First, due to lack of appropriate data, we do not observe the characteristics of imported goods nor know which country the goods are from. The learning effects may vary with trade partners and imported goods. To take an example, firms may learn more from inputs from advanced countries than those from less-developed countries. We may also hypothesize that new knowledge is more likely to be embodied in complicated goods than in simple goods. This paper is unable to test these potentially important predictions. We believe extending research in this direction is valuable, but it requires an elaborate data set which matches importing firms to imported goods or to exporting countries. Second, the SBA survey, the data set we use in this paper, includes firms employing 50 workers or more and thus leaves small sized firms out. One can make a case that the learning effect is more pronounced in small firms than in large firms. It may partially explain why the learning effect is weak in this paper. Further research is needed.

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Appendices

Table A-1 displays the estimated effects of importing on productivity for sub-samples by firm size and R&D intensity. We divide the sample into five groups based on quintiles of firm size and R&D intensity, and estimate the productivity effect according to equation (2).

Table A-2 Reports the productivity effects of importing by industry groups. We divide the sample into seven industry groups, and estimate the effects of importing on productivity for each group according to equation (2).

Table A-1. Effects of Importing on Productivity by Firm Size and R&D Intensity

	s=1	s=2	s=3	s=4	N
Firm size					
~20th percentile	-0.019	0.024	-0.065	-0.017	Treated: 60
	(0.078)	(0.095)	(0.100)	(0.085)	Untreated: 268
20~40th percentile	-0.000	0.101	0.049	0.058	Treated: 52
	(0.059)	(0.077)	(0.075)	(0.086)	Untreated: 258
40~60th percentile	0.019	0.061	0.061	0.110	Treated: 62
	(0.047)	(0.067)	(0.069)	(0.080)	Untreated: 267
60~80th percentile	-0.020	-0.004	-0.019	0.045	Treated: 78
	(0.071)	(0.067)	(0.066)	(0.100)	Untreated: 237
80th percentile~	-0.017	0.026	0.017	0.024	Treated: 122
	(0.049)	(0.067)	(0.060)	(0.067)	Untreated: 206
R&D intensity					
~20th percentile	0.046	0.055	0.091	0.111	Treated: 105
	(0.057)	(0.065)	(0.065)	(0.070)	Untreated: 461
20~40th percentile	0.067	0.066	-0.115	0.006	Treated: 19
	(0.135)	(0.118)	(0.249)	(0.160)	Untreated: 60
40~60th percentile	0.009	0.067	0.061	0.012	Treated: 74
	(0.053)	(0.065)	(0.065)	(0.068)	Untreated: 255
60~80th percentile	0.069	0.072	0.085	0.099	Treated:80
	(0.087)	(0.078)	(0.103)	(0.160)	Untreated: 236
80th percentile~	-0.070	0.011	-0.023	0.021	Treated: 96
	(0.046)	(0.065)	(0.064)	(0.078)	Untreated: 227

Note: In parentheses are the heteroskedasticity-consistent standard errors proposed by Abadie and Imbens (2006). ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively.

Table A-2. Effects of Importing on Productivity by Industry Groups

	s=1	s=2	s=3	s=4	N
Food and Apparel	-0.068	-0.031	-0.085	-0.077	Treated: 75
	(0.094)	(0.115)	(0.126)	(0.133)	Untreated: 215
Rubber and Plastics	0.087	0.019	-0.018	-0.075	Treated: 27
Products	(0.082)	(0.119)	(0.159)	(0.139)	Untreated: 103
Fabricated Metal Products	-0.011	-0.117	-0.018	-0.050	Treated: 18
	(0.102)	(0.129)	(0.135)	(0.144)	Untreated: 101
Electronic Components and	-0.043	0.057	0.115	0.038	Treated: 39
Computer	(0.076)	(0.143)	(0.106)	(0.133)	Untreated: 98
Machinery and Equipment	-0.028	-0.029	-0.010	0.021	Treated: 39
	(0.053)	(0.087)	(0.083)	(0.098)	Untreated: 134
Motor Vehicles and Trailers	-0.046	-0.003	-0.040	0.020	Treated: 48
	(0.057)	(0.078)	(0.074)	(0.076)	Untreated: 251
Others	0.018	0.026	0.046	0.101	Treated: 128
	(0.054)	(0.054)	(0.058)	(0.075)	Untreated: 366

Note: In parentheses are the heteroskedasticity-consistent standard errors proposed by Abadie and Imbens (2006). ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively.