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Simultaneity and heterogeneity in import and productivity: Case study of Indonesian manufacturing

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ADB Working Paper Series

**SIMULTANEITY AND HETEROGENEITY
IN IMPORT AND PRODUCTIVITY:
CASE STUDY OF INDONESIAN
MANUFACTURING**

Chandra Putra and
Dionisius Narjoko

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Abstract

This study examines the impact of imported intermediates on plant productivity and the role of plant capability in explaining the heterogeneity of the impact. The study uses a survey database of medium and large Indonesian manufacturing establishments from 2000 to 2015. Imported intermediates are presented as a proportion of total intermediates, while capability factors are represented by the plant's age, foreign direct investment (FDI) status, exporting status, and capital intensity. This study finds that import intensity does not significantly affect productivity. However, the impact of import intensity on productivity is positive and significant for exporters and for plants with higher capital intensity. Meanwhile, older and FDI plants do not seem to differ in terms of productivity gain from higher import intensity compared to either younger or non-FDI plants. The result underlines the importance of plant capability in determining productivity gain from imported intermediates. The study improves policymakers' understanding for better outcomes in the industry, such as the purpose of trade negotiation. The study also recommends that policymakers carefully consider implementing a restriction or ban on imported intermediates, as doing so will penalize capable firms and reduce the competitiveness of exporters in the global market.

Keywords: imported intermediates, productivity, capability, technology transfer

JEL Classification: D22, D24, F14, F61

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1. INTRODUCTION

A typical rational policymaker in developing countries prefers firms to adopt more sophisticated or better technology as it increases productivity (competitiveness), which should guarantee prospects for growth. A policy tool that is usually used to achieve this objective is foreign direct investment (FDI) because of the expected advanced technology and knowledge brought by the investment. Once established, the positive impact of FDI is expected to spill over to other firms, especially domestic firms, in respect of the development strategy, which can magnify the overall positive effect of FDI on a country's competitiveness.

The FDI channel is well covered in the literature. There are numerous empirical findings that support the positive impact of FDI on productivity through both the instalment of advanced technology and technology spillover. However, the literature does not yet well cover the impact of other possible channels, with a focus on international trade—exports, imports, or both.

This paper addresses the importance of imports. This is important at least for two reasons: firstly, to gain more knowledge on the detail or mechanics of the channel; and secondly, to acknowledge the greater potential positive impact as more and more developing countries engage in free trade agreements (FTA) with their developed country trade partner. If import channels are confirmed and better understood, there will be more to justify the deeper or wider engagement of developing countries in FTAs.

Specifically, this paper explores the aspect of simultaneity in the decision to import in the context of productivity improvement. While there seems to be a consensus in the literature on the positive impact of importing on productivity/competitiveness that comes from superior technology embedded in imported input, it is not very clear whether the other direction of causality also exists—i.e., more productive firms demand higher quality, or better, imported inputs.

This study proposes a way to qualify this endogeneity by comparing the effect of importing on the productivity of two groups of firms, defined by several firm characteristics that can partially represent productivity, such as firm age, FDI status, export status, and capital intensity. As an example, young firms are presumably less experienced and have not yet accumulated much information about the industry, and therefore will choose the source of imports more randomly than older/more experienced firms. Endogeneity could therefore be at least minimized in the estimates of young firms. Similar logic should also apply to other characteristics. This is the main general hypothesis to be tested by this study.

It is also important to note that we consider those firm characteristics as a proxy for a firm's ability to process imported input. This reflects the essence of the idea that a firm needs some specific higher level of productivity to be able to process the higher quality imported input.

The rest of this paper is organized as follows. Section 2 briefly reviews the literature and connects it to the objective of this study. Section 3 describes the data that are used in this study, while section 4 outlines the econometric strategy to test the main hypothesis. Section 5 presents the potential policy relevance deriving from this study.

2. LITERATURE REVIEW

Technology transfer has long been the interest of research in international economics. Starting from the north-south model of endogenous growth (e.g., Grossman and Helpman 1995) that posited an incentive from the south to seek advanced technology from the north driven by the prevailing lower wage level in the south, a large body of works has attempted to test the theory by looking for evidence of technology transfer from the north to the south, which is generally captured by increased productivity in the south. While findings are mixed, one general observation is that the north-south model seems to have motivated countries, especially developing countries, to engage in more open trade and investment policy, fueling greater globalization.

The literature has developed to encompass various strands of more focused study addressing the channels through which technology transfer is feasible, three being identified so far—FDI, exporting, and importing. A large body of work has documented the FDI (e.g., Blomstrom and Kokko 1998; Keller 2004; Takii and Narjoko 2020) and exporting channels (e.g., Aw et al. 2000; Bernard and Jensen 1999; Blalock and Gertler 2004), the latter specifically referring to the ‘learning by exporting’ (LBE) hypothesis as the mechanism that allows the technology transfer. The importing channel has been much less explored: only a handful papers address this channel up to this point.

As in the other channels, there are two mechanisms by which technology transfer from importing can improve the productivity of firms in the manufacturing sector. The first is through the direct positive effect on productivity of the importer by importing much higher quality input. The literature on international trade sometimes labels this the ‘learning by importing’ (LBI) hypothesis, which is one factor explaining the positive bi-directional relationship observed between productivity and importing.¹ The hypothesis argues that advanced technology is embodied in the quality of the imported input and the firm learns how to use it to increase the value and quality of its output. There is a learning process in this mechanism, and this feeds back to increase the firm’s level of technological adoption slowly over time.

The second mechanism is through the exposure of the advanced technology embedded in the imported inputs to domestic suppliers (Blalock and Veloso 2007). Domestic suppliers of intermediate inputs compete as well as learn from imported inputs that have brought in them the essence of R&D being done in foreign/developed countries. The spillover mechanism arguably may serve as another form of LBI, but the mechanism now works for the domestic suppliers instead of the domestic users of intermediate inputs as explained in the first mechanism.

Among the thin literature on the import channel Augier et al. (2013), Fernandez (2007), and Kasahara and Rodrigue (2008) found a positive impact of importing on firms’ productivity in Spanish, Colombian, and Chilean manufacturing, respectively, underlining the direct mechanism of the impact of imports on the importers. Using data from Hungarian manufacturing firms, Halpern et al. (2015) found that using both domestic and foreign inputs is more efficient than using only domestic inputs, and that the productivity gain from imported inputs is higher than from domestic inputs.

¹ The other direction gives rise to self-selection into the importing market that commonly leads to the positive impact of productivity on importing. The bi-directional positive relationship between productivity and importing is derived directly as a consequence of the theoretical explanation of firm export behavior (Bernard et al. 2007). A review of the literature that considers exports and imports in the theoretical idea of self-selection and learning is provided by Wagner (2012), for example.

Kasahara and Lapham (2013) conducted several counterfactual experiments on firms with different exporting and/or importing status using Chilean plant-level manufacturers for the period 1990 to 1996. They found a large welfare gain for firms involved in these trading activities. More importantly, they validated the complementary nature of importing and exporting and showed its high significance. Thus, it is implied that policies that inhibit the importation of foreign intermediates will likely generate a negative impact on the exportation of final goods. Separately, Bernard et al. (2012) saw this complementarity as the natural response of firms engaging in international trade, as their technology is characterized by increasing returns to scale, meaning that firms (exporters or importers) need to produce enough to balance their efficient average production cost. The authors argued that this should explain why exporters and importers are typically very large firms and are connected globally by producers and distributor networks, commonly known as firms in global value chains (GVC).

Blalock and Veloso (2007), meanwhile, found a productivity gain from imports among firms in other industries—that is, firms supplying to the industry that imports intensively. This underlines the learning effect and provides stronger evidence for the existence of a spillover effect from imported goods, as the productivity gain happens in an industry other than the industry experiencing the high import intensity. An implicit message supporting Blalock and Veloso comes from Amiti and Konings (2007), who found that a reduction of tariffs on intermediate inputs has a positive impact on productivity that happens via learning, the introduction of more variety, and the quality effect.

Contrasting the findings from these studies, some studies present a conflicting message. For example, analyzing US multinationals globally, Keller and Yeaple (2009) concluded that imports do not influence plant productivity after controlling for endogeneity. Similarly, Muendler (2004) did not find a productivity gain from importing among importers in Brazilian manufacturing. However, he did find a similar vertical spillover effect to that found by Blalock and Veloso (2007) in Indonesian manufacturing, where the imports apparently increase the productivity of domestic (Brazilian) firms supplying intermediate input to the importers. An even more striking result comes from Sharma and Mishra (2015), who found from data on mostly Indian listed companies that starting, continuing, and stopping the importation of inputs negatively affect productivity.

Blalock and Veloso (2007) outlined two potential reasons for the conflicting findings. The first is the cost-benefit factor. High-quality input will only be imported if the cost of obtaining it is less than the value of the new technology embodied in the input. Therefore, if there is a local producer that can produce exactly the same quality input as the imported one, which means using the same level of technology as is embodied in the imported input, the firm will no longer import the input. The second reason is econometric. There is an endogeneity issue in that it is difficult to control whether the decision to import really follows a random process. The decision to import high quality may be taken because the firm is already very productive. In other words, there could be reverse causality running from productivity to importing, or simultaneity for both directions of causality.

Besides looking for the relationship between importing and productivity, this study also proposes to show the extent of simultaneity by using several firm characteristics—the firm's age, FDI status, export status, and capital intensity—to represent the firm's capability to absorb technology from imports. The argument is that older firms, firms with FDI, exporting firms, and more capital-intensive firms are associated, at least partially, with greater productivity, and vice versa. By examining the effect of importing on productivity for different groups of firms defined by these characteristics, we examine in detail everything we can learn about the simultaneity relationship and its

heterogeneity. Empirical works on this topic can be found. For example, Okafor et al. (2017) found that Ghanaian manufacturing firms with higher absorptive capacity enjoy a higher productivity gain from imported inputs,² while Augier et al. (2013) showed that the significance of this absorptive capacity is evident from the existence of more skilled workers hired by importing firms. Furthermore, exporters are expected to be more able to increase productivity from imports than non-exporters. This logic should also apply for the other characteristics.

3. DATA

This study utilizes Statistik Industri (SI), the annual survey of medium and large manufacturing establishments conducted by Badan Pusat Statistik (BPS), the Indonesian statistical agency). SI data contain a number of plant-level variables such as the business code, number of workers, production output, foreign ownership, and other variables.³ A plant's business code is recorded as a five-digit Klasifikasi Baku Lapangan Usaha Indonesia (KBLI)—that is, a unique five-digit extension of the International Standard Industrial Classification (ISIC) in Indonesia.⁴ The sample period for analysis is from 2000 to 2015, although some variable measurements may involve earlier SI data (e.g., plant age is measured using 1990–2015 SI data).

To complement the plant-level SI for empirical analysis, we also utilize the intermediate-input-level SI for descriptive analysis. The intermediate-input-level SI data come from the same survey and provide the intermediate input expenditure for each plant at a detailed nine-digit Klasifikasi Komoditas Indonesia (KKI) product level. The KKI is a unique nine-digit extension of the five-digit KBLI 2000 and the four-digit ISIC revision 3 in Indonesia. The records of intermediate input expenditures are available in total from domestic sources and from imports. Because of numerous missing values in 2000–2006, we use the 2007–2015 period of intermediate-input-level SI for descriptive analysis.

4. METHODOLOGY

We begin the analysis with the fundamental relationship between import intensity (MI) and productivity ($PROD$) as follows.

$$PROD_{ft} = \beta_1 MI_{ft} + \beta_2 CV_{ft} + \phi_f + \phi_t + \phi_s + \varepsilon_{ft} \quad (1)$$

$$PROD = \{LP, TFP\} \quad (2)$$

$$CV = \{\ln(age), d(FDI), d(export), \ln(capin), \ln(mat), \ln(size), \ln(size)^2\} \quad (3)$$

² Absorptive capacity in Okafor et al. (2017) is represented by the gap between one-lagged productivity and initial productivity for each firm in the sample.

³ We use the term 'firm' mostly in the literature review and 'plant' in our data and subsequent analysis. A firm can be a single-plant firm or a multi-plant firm. The SI 2006 edition has the latest records on firm identification, where around 5.9% of the plant sample identify themselves as part of a company group (i.e., a firm).

⁴ Different versions of the KBLI (2000 and 2009) are related to different versions of the ISIC (revision 3 and revision 4). We convert KBLI 2009 to KBLI 2000 for analysis.

The subscripts f , t , and s represent the plant, year, and two-digit KBLI 2000 sector, respectively. Import intensity is measured by the ratio of the value of imported input to the total value of inputs used by a plant.

There are two alternative measures for productivity, labor productivity (LP) and total factor productivity (TFP). Labor productivity is measured as follows.

$$LP_{ft} = \frac{Y_{ft}}{size_{ft}} \times \frac{100}{WPI_{ft}} \quad (4)$$

Y and WPI represent the gross output and wholesale price index, respectively. Meanwhile, TFP is measured using the Levinsohn-Petrin method with Cobb Douglas production function and labor, capital, and intermediate materials as production factors.

CV is a set of control variables which are the plant's age, FDI status ($d(FDI)$, 1 if a plant has at least 1 % foreign ownership and 0 otherwise), export status ($d(export)$, 1 if a plant exports and 0 otherwise), capital intensity ($capin$), intermediate material (mat), and number of employees ($size$) and its quadratic form. Lastly, the model in equation (1) also includes plant, year, and sector fixed effects.

The plant's age can be measured using two methods: firstly, by using the 'year of establishment' variable which, unfortunately, was not available for all years of the survey;⁵ and secondly, by using the gap between the current year of observation and the first year a plant appeared in the sample of 1990–2015 SI data. In this method, the maximum age is 26 years, and so 26 years also represents the unobserved older age. We use the second method in our experiment, since the second method covers more of the sample (more than 99% of observations) than the first method (around 89% of observations).

Because of the lack of capital data availability in SI data, capital intensity is proxied using the energy expenditure ($energy$) per production laborer ($prod.labor$).

$$capin_{ft} = \frac{energy_{ft}}{prod.labor_{ft}} \times \frac{100}{WPI_{ft}} \quad (5)$$

The logic behind such a proxy is that a capital-intensive plant is more likely to have more machinery handled by each of its laborers; thus, is more likely to spend more on energy per laborer for those machines. We also deflate the intermediate materials (mat) with WPI, assuming a pass-through correspondence between the price of a bundle of intermediates and the price of the output product.

Our second experiment tests the heterogeneity impacts of importing on productivity across a number of plant characteristics which we deem representative of capability, namely the plant's age, FDI status, export status, and capital intensity. We do this by interacting each of the capability variables with import intensity.

$$PROD_{ft} = \beta_1 MI_{ft} + \beta_2 MI_{ft} \times INT_{ft} + \beta_3 CV_{ft} + \phi_f + \phi_t + \phi_s + \varepsilon_{ft} \quad (6)$$

$$INT = \{\ln(age), d(FDI), d(export), \ln(capin)\} \quad (7)$$

⁵ We use the 1990–2000 and 2006 SI data for this method.

From equation (6), we will have four different specifications according to each capability variable (*INT*) in (7). Equations (1) and (6) will be estimated by panel fixed-effect method.

Endogeneity Issue and Robustness Checks

As we can see from Equations (1) and (6), all independent variables are potentially endogenous. The form of endogeneity problem is simultaneity, where, for example, import activity may improve the plant's productivity and the plant may increase its import appetite because it experiences an increase in productivity. Meanwhile, the chance of the models suffering from omitted variable bias is likely to be minimized by the inclusion of three effects, as well as by the inclusion of the selected independent variables in the models.

Thus, we deal with the endogeneity issue by using alternative methods to estimate Equations (1) and (6), namely by using instrumental variables (IV). We use the average values of each endogenous variable in a specific region, sector, and year as instrumental variables. We assume that an individual plant's decision on exporting, for example, is influenced by the collective decision of its surrounding businesses, but not the other way around.

5. EMPIRICAL RESULTS

This section presents some descriptive analyses from the average-level comparison of a number of performance measures by types of plant defined by their characteristics. The measures considered here are the following: intermediate input scope, types of intermediate input—i.e., more productive or less productive intermediate input, and import intensity. Input scope is the number of intermediate input products defined by the nine-digit KKI (product code).

More and less productive inputs are proxied by those used only by the more and less productive plants, respectively, the difference in productivity being defined here by separating the distribution of TFP to above or below its median value for the more productive or less productive group of plants, respectively.

Table 1 presents these average-level measures according to the considered plant characteristics—i.e., productivity (measured by TFP and labor productivity), age, FDI participation, export participation, and capital intensity, as proxied in Equation (5). There are interesting observations from the table. Firstly, imports are needed for more than half of the intermediate products used by manufacturing plants. This is clear by comparing the scope of intermediate input with the total input used and that coming from imports. Consistently across the productivity measures and the other characteristic measures that represent capability in processing input (i.e., age, FDI, exporting, and capital intensity), the scope of imported intermediate input is on average around two out of the total of three inputs used by plants. For example, on average, higher productive plants defined by TFP use 2.11 imported inputs, while the total input used by these plants is 2.78 inputs. Similarly, older plants used 2.18 imported inputs on average while the total inputs used was 2.84 on average.

Table 1: Intermediate Input Statistics by Plant Characteristics, 2007–2015

Variables	TFP		Labor Productivity		Age	
	Lower	Higher	Lower	Higher	Younger	Older
Total intermediates						
Intermediate scope	3.09	2.78	2.90	2.58	2.59	2.84
Imported intermediate scope	2.27	2.11	2.19	1.99	1.73	2.18
Import intensity	7.0%	17.1%	6.2%	16.6%	11.9%	12.3%
Less productive intermediates						
Share to total intermediate scope	37.2%	0.0%	30.9%	7.0%	20.8%	18.8%
Import intensity	6.7%		5.1%	16.3%	5.7%	8.1%
More productive intermediates						
Share to total intermediate scope	0.0%	37.1%	7.3%	30.5%	18.0%	21.4%
Import intensity		19.2%	14.8%	19.8%	20.9%	19.2%
Common intermediates						
Share to total intermediate scope	62.8%	62.9%	61.8%	62.5%	61.1%	59.8%
Import intensity	7.9%	15.2%	6.5%	15.7%	10.4%	12.2%

Variables	FDI		Exporting		Capital Intensity	
	No	Yes	No	Yes	Lower	Higher
Total intermediates						
Intermediate scope	2.71	2.45	2.74	2.62	2.70	2.58
Imported intermediate scope	1.99	2.07	1.97	2.20	1.74	1.89
Import intensity	8.0%	33.4%	8.4%	26.3%	8.7%	16.1%
Less productive intermediates						
Share to total intermediate scope	22.2%	10.8%	22.9%	14.9%	23.3%	13.4%
Import intensity	5.9%	26.4%	5.8%	20.3%	4.7%	12.7%
More productive intermediates						
Share to total intermediate scope	18.0%	31.9%	16.2%	29.7%	16.4%	24.2%
Import intensity	12.5%	38.6%	12.4%	31.2%	16.0%	20.9%
Common intermediates						
Share to total intermediate scope	59.8%	57.3%	60.8%	55.4%	60.3%	62.4%
Import intensity	8.6%	32.7%	8.5%	23.2%	8.8%	13.8%

Notes:

- Plant categories (lower or higher) for TFP, labor productivity, age, and capital intensity are defined by median cut-off points for each four-digit sector at plant-year-level sample. For example, using the plant-year-level sample, a plant's TFP is considered higher if it is above median TFP at four-digit sector and is considered lower if it is below or the same value with median TFP.
- Each of the variables is aggregated from the plant-year-product-level sample to the plant-year-level sample, to the (four digit) sector-year-level sample, and to the final single value. All aggregations are in the form of a simple average.
- Less productive, more productive, and common intermediates are intermediates that are exclusively used by lower TFP plants, by higher TFP plants, and by both lower and higher TFP plants, respectively.

Source: Statistik Industri; authors' calculations.

In addition, it is interesting to observe that more productive or more capable plants (i.e., older, foreign plants, exporters, or highly capital intensive) do not always use more input than the less capable ones. While deeper examination is needed, this may be because more capable plants are importing more 'completed' or 'built' parts and components (PC), while the less capable plants may have used more incomplete PC, requiring them to do more assembly activity within the plants.

Around a third of intermediates are used exclusively by either less productive plants or more productive plants, while around two thirds of intermediates are used by all plants regardless of their level of productivity. Specifically, around 63% of the total intermediate inputs are used by both more and less productive plants, while only 37.1% of the total input is used only by more productive plants and 37.2% only by less productive plants.

This is a very important finding in our view, showing that there are indeed some different intermediates used by less and more productive plants. There is something unique in intermediate inputs attached to different productivity levels, and this could be the result of many factors. Understanding this in greater detail may uncover or confirm past research on the source of productivity growth. While it is the subject of other studies, in this study we will check whether several characteristics explain the source of the difference.

As stated in Table 1, this study argues that only inputs used by less productive firms can be defined as less productive intermediates, while only inputs used by more productive plants can similarly be defined as more productive intermediates.

Cross-examining the productivity of the intermediate inputs and the plant capability across four different considered characteristics, there is a pattern that more capable plants use a greater number of more productive intermediates, while less capable plants use a greater number of less productive intermediates.

The share of more productive intermediates among the total intermediates is consistently higher for older plants (21.4% vs. 18%), foreign plants (31.9% vs. 18%), exporters (29.7% vs. 16.2%), and highly capital-intensive plants (24.2 vs. 16.4). Capability in absorbing, or processing, intermediate inputs therefore go hand in hand with productivity, suggesting a positive relationship between capability and the productivity level of intermediate inputs.

Except for the age factor, more capable plants have a higher import preference across all types of intermediates than less capable ones. Moreover, this difference is rather high, especially between foreign and domestic plants, and between exporters and non-exporters. To illustrate, foreign plants' import of more productive intermediates accounts for up to 38.6% of the total intermediates they use, which is significantly different from the quantity of more productive intermediates used by domestic plants, at 12.5%. Similarly, exporters' import of more productive intermediates accounted for up to 31.2% of the total intermediates they used, significantly higher than the 12.4% used by non-exporters. The statistics here show that capability this time goes hand in hand with import preference.

Overall, there is higher import preference for the more productive intermediates than for the less productive intermediates, or the intermediates commonly used by all plants with varying productivity. Assuming that the difference in the productivity of intermediate inputs represents a difference in quality (i.e., less productive, common, and more productive intermediates represent low, medium, and high quality, respectively), one can expect that import preference is higher for high quality intermediate inputs.

The rest of this section reports the results of the econometric estimations. Summary statistics of all variables involved in the estimation are presented in Table 2. The estimates for Equation (1) are presented in Table 3, which shows two measures of productivity, TFP and labor productivity, and two regression approaches, ordinary least squares (OLS) and IV. Most parameters differ at least in terms of scale across regression methods, indicating the existence of endogeneity in the model. Endogeneity

tests show that the presumed variables are indeed endogenous, and therefore the IV approach should be preferred to OLS. In the IV models, the underidentification tests (Kleibergen-Paap LM statistics) show that the instruments used in the IV approach are valid. The weak-identification tests (Kleibergen-Paap Wald F statistics) are quite high, indicating that the instruments are strong in explaining the endogenous variables.

Table 2: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
TFP (in thousands)	198,415	20.9	155	0.018	19,189
Labor productivity (million IDR, const. 2,000 prices)	286,177	145	2,418	0.002	1,150,408
Import intensity	286,177	0.094	0.245	0	1
Age	286,177	9.24	6.56	0	25
Export dummy (1 if exporting)	286,177	0.191	0.393	0	1
FDI dummy (1 if foreign ownership > 10%)	286,177	0.088	0.283	0	1
Capital intensity (million IDR, const. 2,000 prices)	286,177	15.3	208	0.000	54,555
Intermediates (billion IDR, const. 2,000 prices)	286,177	21.2	229	0.000	43,093
Number of employees	286,177	197	744	20	50,000

Source: Statistik Industri BPS; author's calculations.

Table 3: Baseline Model

Variables	OLS		IV	
	ln(TFP)	ln(LP)	ln(TFP)	ln(LP)
	[1]	[2]	[3]	[4]
Import intensity	0.341*** (0.023)	0.023** (0.009)	0.054 (0.121)	-0.093 (0.066)
ln(age+1)	-0.006 (0.006)	-0.001 (0.003)	0.209*** (0.047)	0.072*** (0.024)
d(FDI)	0.031* (0.017)	0.039*** (0.009)	0.412*** (0.145)	0.208*** (0.077)
d(export)	0.002 (0.006)	0.019*** (0.004)	0.211*** (0.038)	0.095*** (0.026)
ln(capital intensity)	0.154*** (0.002)	0.159*** (0.002)	0.177*** (0.026)	0.150*** (0.017)
ln(intermediates)	0.277*** (0.004)	0.536*** (0.003)	0.368*** (0.026)	0.626*** (0.017)
ln(labor)	0.181*** (0.020)	-0.452*** (0.015)	0.099 (0.312)	-0.411** (0.192)
ln(labor)^2	-0.014*** (0.002)	-0.013*** (0.001)	-0.020 (0.028)	-0.021 (0.017)
Fixed effects: plant, year, and sector	Yes	Yes	Yes	Yes
Observations	196,179	286,177	190,334	286,166
R-squared	0.935	0.931		
Kleibergen-Paap LM statistic			270	445
[p-value]			[0.000]	[0.000]
Kleibergen-Paap Wald F statistic			30.7	52.7
Endogeneity test			168	152
[p-value]			[0.000]	[0.000]

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Among the variables used to explain productivity using the IV approach, export, capital intensity, and intermediate values significantly influence productivity in the expected directions. The number of employees negatively affects labor productivity, also as expected, but is insignificant in TFP model. Meanwhile, the parameters of import intensity are insignificant in both the OLS and IV approaches. This shows that, on average, manufacturing plants in Indonesia do not gain productivity improvement from increasing the proportion of imports in their intermediates.

The insignificant parameters of the imported intermediates in the IV models might be related to the plant capability. Capable plants are able to fully absorb and to further process the technology embodied in the imported intermediates, while less capable plants may not be able to gain much from them. In the long run, less capable plants may even be too dependent on imported inputs and not try enough to increase their capability further; thus, they may experience a loss in long-run productivity. The role of capability for plants to gain from import activity will be inspected in the next experiment.

Table 4 presents the IV models, each with an interaction between import intensity and one of the capability variables as in Equation (6). From the table, we can see that export participation and capital intensity are among the variables that can capture plants' ability to gain more from importing intermediates. This shows that exporting activity and higher capital intensity are needed for plants to gain more than their counterparts (i.e., non-exporting and less capital-intensive plants, respectively) from imported intermediates.

Table 4: IV Models with Heterogenous Impacts of Import Intensity

Variables	ln(TFP)				ln(LP)			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Import intensity (MI)	-0.024 (0.176)	0.030 (0.134)	-0.162 (0.127)	-0.955*** (0.305)	-0.164** (0.079)	-0.037 (0.080)	-0.209*** (0.072)	-0.543*** (0.201)
ln(age+1)	0.185*** (0.062)	0.205*** (0.052)	0.191*** (0.046)	0.199*** (0.047)	0.047* (0.028)	0.079*** (0.025)	0.066*** (0.024)	0.069*** (0.024)
MI * ln(age+1)	0.045 (0.070)				0.051 (0.033)			
d(FDI)	0.417*** (0.145)	0.381** (0.178)	0.325** (0.148)	0.398*** (0.145)	0.204*** (0.077)	0.283*** (0.101)	0.142* (0.083)	0.206*** (0.077)
MI * d(FDI)		0.099 (0.382)				-0.221 (0.176)		
d(export)	0.203*** (0.040)	0.210*** (0.038)	0.062 (0.044)	0.199*** (0.038)	0.085*** (0.027)	0.098*** (0.027)	-0.003 (0.032)	0.089*** (0.026)
MI * d(export)			0.771*** (0.181)				0.471*** (0.115)	
ln(capital intensity)	0.177*** (0.026)	0.178*** (0.026)	0.166*** (0.026)	0.154*** (0.026)	0.151*** (0.016)	0.149*** (0.017)	0.146*** (0.017)	0.142*** (0.017)
MI * ln(capital intensity)				0.144*** (0.041)				0.061** (0.026)
ln(intermediates)	0.368*** (0.026)	0.368*** (0.026)	0.376*** (0.026)	0.376*** (0.026)	0.625*** (0.017)	0.626*** (0.017)	0.630*** (0.017)	0.625*** (0.017)
ln(labor)	0.119 (0.307)	0.108 (0.309)	0.219 (0.316)	0.080 (0.314)	-0.373* (0.191)	-0.437** (0.191)	-0.331* (0.195)	-0.412** (0.192)
ln(labor)^2	-0.022 (0.028)	-0.021 (0.028)	-0.032 (0.029)	-0.017 (0.029)	-0.024 (0.017)	-0.019 (0.017)	-0.029 (0.018)	-0.021 (0.017)
Fixed effects: plant, year, and sector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	196,178	196,178	196,178	196,178	286,166	286,166	286,166	286,166
Kleibergen-Paap LM statistic	281	275	267	269	453	449	432	445
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Kleibergen-Paap Wald F statistic	28.4	27.8	27.1	27.2	47.7	47.3	45.5	46.8
Endogeneity test	169	163	169	174	150	154	168	168
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, and * p<0.1.

Age and FDI factors do not seem to represent capability of gaining from imported intermediates. However, the parameters of standalone age and FDI variables are both positive and significant. This shows that the productivity edge of older and FDI plants over its younger and domestic counterparts, respectively, lies in the impact of age and FDI themselves and not in gaining more from imported intermediates.

6. CONCLUSION

The findings from this study are expected to deepen our understanding of the validity of the import channel for technology transfer and to qualify the mechanisms by which the channel typically happens in practice, as a result of controlling for the potential endogeneity from simultaneity.

This study found a number of characteristics to be associated and have some role in facilitating technology transfer that comes through importing, presumably through the superior quality of imported inputs.

Deeper examination of the data reveals that, indeed, two characteristics matter in facilitating technology transfer through imports—that is, exporting and capital intensity. The idea of building up capability within the firm to process imports, which means undertaking the process of technology transfer, seems to occur in exporters and more capital-intensive plants.

Assuming that technological transfer through imports can be realized when the imported intermediates themselves are better in terms of quality, it seems obvious that better machinery (thus, higher capital intensity) is needed to better process the imported intermediates. To break into international markets, plants also need to reach a certain level of product quality, and one facilitator is using better quality intermediates, which sometimes need to be procured from imports.

While from the outset it seems convincing that foreign firms are very capable in terms of processing inputs, deeper examination using an econometric method reveals that the productivity edge of FDI plants over their domestic counterparts lies in the impact of FDI itself and not in terms of gaining more from imported intermediates. All this suggests that the dominant source of foreign firms' competitive edge comes from the very robust, or the most advanced, technology that they bring from overseas, cutting short the time needed for a firm to learn to process the imported input, as may likely be the process that happens in exporters or more capital-intensive plants. A similar thought process can be applied to the plant age, where older plants may have more experience of arranging their sourcing options for intermediates, modifying domestic intermediates to achieve a higher level of quality, or even further arranging a network of domestic suppliers attuned to their specific demands from intermediates.

From a policy perspective, the study findings further qualify the importance of importing for technological development. This should provide more clarity and confidence for policymakers in dealing with some of the detail or focus in industrial and trade policymaking. For example, the findings could be useful for trade negotiations, especially if there are some systematic patterns across industries, which should help the negotiators to direct or target the commitment to tariff or non-tariff reductions across products.

This study recommends that policymakers carefully consider the consequences of implementing barriers on imported intermediates such as a local content requirement or import ban. This policy penalizes more capable manufacturers such as exporters or capital-intensive plants, which undoubtedly play a big role in the economy, in the form of productivity loss and an inability to learn from the foreign technology embedded in imported intermediates. Especially for exporters, productivity loss can further reduce their ability to compete with exporters from other countries, which can lead them to exit the export market and hinder the export performance of the economy.

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