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The role of imported inputs in firms' productivity and exports: evidence from Indonesia

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Abstract
The rise of economic protectionism worldwide has come with the re-emergence of mercantilist policies whereby governments push for exports while restricting imports. Against this populist approach, we show that importing inputs can raise productivity and export. Using firm-level data matched with very detailed customs data of Indonesia's exports and imports during 2008–2012, we apply instrumental variable strategy with import tariffs and import weighted real exchange rates as instruments for import of intermediate inputs. We find causality from imported inputs to productivity increase and export growth. Higher access to input varieties has a larger impact than an increase in import volume on export, implying that the main benefits of importing may come from access to broader alternatives of inputs. Furthermore, the impact is also larger when imports originate from developed countries, suggestive of a positive effect of technology and product quality.

Keywords Imported intermediate inputs · Export performance · Total factor productivity

JEL Classification D22 · D24 · F13 · F14 · F31

1 Introduction

The rising interconnectedness among production centres around the world has highlighted the role of imported intermediate inputs in manufacturing process. The increasing degree of vertical specialisation has escalated the use of imported inputs

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in production as well as in exports (Hummels et al., 6). From the perspective of a single country (or a firm), imported inputs are essential as the source of productivity-enhancing technology. Especially for trade in parts and components, imported inputs has become a 'ticket' to participate in global production sharing (GPS) (Pierola et al., 6). Firms work together to produce final products by building cross-country production networks or relationships with buyers and suppliers. As a result, the flow of unfinished goods has increased across economies and trade in intermediate goods has now surpassed half of the total world trade (Johnson & Noguera, 6).[1]

The advantage of using imported inputs in production is significant. Theoretically, Ethier (6) and Markusen (6) predict the gains from imported inputs due to a finer division of labour. Recent empirical studies have found evidence that importing intermediate inputs increase firms' productivity (Amiti & Konings, 2; Bas & Strauss-Kahn, 6; Halpern et al., 6; Kasahara & Rodrigue, 6), product scopes (Damijan et al., 6; Goldberg et al., 6) and product quality (Bas & Strauss-Kahn, 6; Fan et al., 6). The learning process made possible by technologies embodied in the variety of imported inputs has been recognised as a channel by which firm's performance can increase. This can take different mechanisms. First, higher quality of imported intermediate inputs may increase the quality of the final product, thus increase the demand for the firm's product, and subsequently raise profitability. Moreover, utilising more imported input varieties that are not available domestically can provide additional gains through product innovation that may increase revenues. Second, imported inputs can help reduce the costs of production, as they are often more affordable than domestic inputs. Third, imported inputs help increase the efficiency of the division of labour and thus firm's overall productivity (Feng et al., 6).

To date, however, the effect of imported inputs on exports in the micro-level has been relatively under-explored. Two of the few recent studies are Bas and Strauss-Kahn (6) on France, and Feng et al. (6) on China. These studies have empirically shown the significant impact of imported intermediate inputs' expansion on a firm's export outcomes. There is another strand of literature that focuses on how imported intermediate inputs relate with exports. Mostly at the country level, studies on global value chains (GVCs) pioneered by Hummels et al. (6), have developed measurements of foreign value-added (or imported inputs) share in a country's exports. The present study expands on the former strand. Our paper adds value to the literature in three ways. First, it provides evidence from a developing economy that is a price taker in the world market (hence, a small, open economy). It complements the evidence from developed economy (Bas & Strauss-Kahn, 6) and from big, developing economy (Feng et al., 6). Second, it offers a causality estimation whereby we instrument import activities with import tariffs and exchange rate dynamics with a

[1] We define intermediate inputs as any material inputs used in production, including parts and components. Later, we analyse parts and components separately.

proper weighting, applied on a rich, unique dataset. Third, we expand the study to look at how developing countries participate in global value chains.

For countries eager to boost their exports while ambivalent towards imports, this research question carries economic and political interests.[2] Therefore, the findings of this study will give insight for policymakers into understanding firms' behaviour, especially their import–export decisions.

This study uses two concepts of imported inputs: the total value of a firm's imported input and the number of varieties of a firm's imported inputs.[3] The relation of total imported values with export may show the general inference of the importance of imported inputs to exports. It could contain the quality- and revenue-increasing effects of imports even though we cannot disentangle these specific effects. On the other hand, the number of import varieties might provide a richer explanation. Broda and Weinstein (6) show that import varieties have become an important source of gains from trade via the 'love of variety' mechanism (Krugman, 6). Some types of intermediate inputs might not be available domestically thus, access on those inputs from foreign countries could increase a firm's capability to produce a certain product. This is relevant with the current developments within international trade where countries (or firms) become more specialised in that there are only a few particular countries (or firms) that are able to produce a specific intermediate input. Furthermore, access to more varieties (product-country pairs) of imported inputs could give a firm the opportunity to be more efficient in expanding its outputs because it has more choices in managing its inputs. A firm can have more alternatives for obtaining a certain input from more than one country (both from domestic and imports) by optimising the price and quality decision; thus, minimising costs and maximising profits. Therefore, the benefits from multiple varieties may enhance the effects of imported inputs on exports.

At the outset, the mechanism of how imported inputs relate to export performance seems straightforward. When a firm decides to scale up its production and to access foreign markets, it also needs to scale up its inputs. While minimising costs, it can choose to source the intermediate inputs domestically or by importation.[4] Given a certain level of productivity, the manager of a firm would estimate the potential costs and revenues from this export-input decision and in so doing pay attention to the

[2] See Patunru (2018) for an example of this ambivalence. Despite such pervasive ambivalence, however, there is ample evidence of how importing inputs correlate positively with exporting final goods. Table 13 and Fig. 1 in the "Online Appendix" show that regions with relatively low import tariffs on intermediate goods used for manufacturing do not only have a higher import of intermediate goods but also a higher export of manufacturing products.

[3] There are many definitions of product varieties. The most commonly used in empirical exercises is by relating the varieties with the available product classifications. This study follows Broda & Weinstein (6) and Bas & Strauss-Kahn (6) who define varieties as product-country pairs.

[4] The framework to analyse a firm-level decision to export introduced by Melitz (6) has inspired many studies to also analyse a firm's import decision. Antràs et al. (4) show that a foreign sourcing (that is, input importing) decision is much more complicated since there is inter-dependency within the sourcing decisions across markets. As an importing firm seeks to lower its marginal costs, the decision to import from one market also affects the decision to import from other markets.

technology and quality embedded in the inputs. But even as the correlation between import and export in firm-level decisions is clear, the causality can be ambiguous. Aristei et al. (5) and Kasahara and Lapham (6) show that there might be a two-way relationship between exporting and importing decisions.[5] These simultaneous decisions make the connection between imports and exports more complicated because they are both functions of the firm's productivity. But understanding the relationship is important for policy makers. If importing inputs are indeed key to improving productivity and export, policy that hinders imports deny such opportunity.

In this study we use the Indonesian firm-level dataset from the Indonesia's Central Bureau of Statistics (BPS), combined with detailed import and export data at the 10-digit harmonised system (HS) product-level and at the country-level (both source of imports and export destinations) from the Indonesian Customs for the period of 2008–2012. These datasets are further merged with a constructed HS 6-digits tariffs and the exchange rate dataset that serve as instruments and control variables. With these datasets we undertake four empirical works.

First, following Kasahara and Rodrigue (6) and Bas and Strauss-Kahn (6), we estimate the total factor productivity (TFP) using the semi-parametric method of Levinsohn and Petrin (6) by incorporating the decision to import intermediate inputs in the production function. We find a positive effect of imported inputs on firm productivity. Subsequently, controlling for the estimated TFP, we investigate how the use of imported intermediate inputs affects export performance. As expected, we find positive impacts of imports on exports.

Second, we attempt to establish causality between import and export, using instrumental variable method proposed by Feng et al. (6). We instrument import activities with two exogenous variables that affect the relative costs of foreign inputs: the changes in intermediate-input import tariffs and the movements of import-weighted exchange rate. Earlier studies have suggested the importance of accessing the intermediate inputs at free trade prices (Keesing & Lall, 6). As shown by Johnson and Noguera (6), the changes in trade frictions, such as tariffs on manufacturing inputs play a major role, particularly for firms engaged in production networks. Changes in import tariffs is a good instrument because it has no direct effect on exports: import tariffs can affect exports only through imported inputs. Many studies have used import tariffs to predict imports (e.g. Amiti & Konings, 2; Bas & Strauss-Kahn, 6). To ensure that the exclusion restriction of the tariffs holds, we apply a weighting procedure that utilises each industry's use of imported inputs.

Firms' import behaviour may also be affected by exchange-rate movements, as discussed in Amiti et al. (1). Hence, we also use exchange rate dynamics as an

[5] There are some explanations for this two-way relationship between exports and imports. First, assuming there are sunk costs associated with both activities, the most productive firms self-select into two-way trade. Second, firms that have previously traded one-way would switch to two-way trade as they see an opportunity to spread the sunk costs between the two activities. The cost of exporting (importing) decreases when the firm in question has already carried out importing (exporting) activities. Third, importing (exporting) may have an effect on exporting (importing) due to the opening up of information channels or because of the indirect channels of productivity—augmentation and innovation.

additional instrument. However, real exchange rates, if measured in the standard way, *can* influence import costs, and have a correlation with exports (Greenaway et al., 6). This will render it a bad instrumental variable. To construct an exchange rate instrument that is free from such direct relation to exports, we implement a weighting procedure that utilises imported input dynamics but excludes export dynamics.

After employing the instrumental variables, we find evidence for causality whereby an increase in imported inputs used in production does enhance the firm's export performance. The effects are amplified when we use the variety (product-country pairs) of imported intermediate inputs as the explanatory variable, implying significant gains from variety.

Third, we extend the analysis by excluding foreign firms as well as firms in a production network (global production sharing, henceforth GPS) that might manage their import–export decisions differently. We find that the impact of imported inputs on exports are more significant for domestic firms and for firms that are not in GPS sectors. There are two possible reasons why the impact is not significant for firms in the GPS sector. Firstly, the lead firm at the headquarters office may give specific directions regarding import–export decisions for multinational firms. Secondly, firms in production sharing may already have time-based contracts regarding import–export activities.

Fourth, to obtain further insights into the channel of how imported inputs affect exports, we explore the links between the source of imports and export destinations. We decompose the import sources and export markets into developed countries, developing countries, East Asian countries and non-East Asian countries. Compared to the baseline of total import and total export, we find that the effect is larger for imports originating from developed countries, suggesting a positive effect of technology and product quality associated with imported inputs. As expected, the technology transfer through imported inputs used in production could improve the firms' performance. We also see that the effect of imported inputs on exports to East Asian countries is much higher and more significant than that to destination countries outside the region. This indicates that imported inputs have helped Indonesian firms to connect to the regional markets.

This study contributes to the growing literature on the relation between imported inputs and firms' performance. First, this study provides additional evidence on the positive effects of imported inputs on firms' productivity in a developing country. Furthermore, this research is one of very few studies that provide a causal evidence of how imported intermediate inputs affect export performance. This study is the first that looks at the experience of a small, open, and developing economy like Indonesia—a country that is less connected to the other trading countries in East Asia region. It thus adds to the previous studies for developed country (Bas & Strauss-Kahn, 6) and for big, developing economy (Feng et al., 6). Finally, the study's highlights of the importance of imported inputs to domestic firms' productivity and export performance can inform policy makers in dealing with increasing call for protectionism and mercantilism —where imports are seen as a threat to the economy. This is especially evident in the country of our study, Indonesia, where the government seems to be going back to import substitution strategy with an array of protectionist measures.

The rest of this paper is structured as follows. Section 2 provides the theoretical framework on how imports of intermediate inputs affect a firm's performance, along with a discussion of the empirical strategy. Section 3 explains the dataset and discusses some stylised facts of import and export activities of manufacturing firms in Indonesia. Section 4 reports the main results followed by some extensions. Section 5 concludes.

2 Theoretical framework and empirical strategy

2.1 Total factor productivity

In estimating the TFP, we closely follow Kasahara and Rodrigue (6). Suppose that to produce total output Y_{it} for each period of t, a firm i uses different types of inputs, namely capital K_{it}, labour L_{it}, energy R_{it} and a set of horizontally differentiated intermediate materials $Z(g)$ that can be domestically sourced or imported:

$$Y_{it} = e^{\omega_{it}} K_{it}^{\beta_k} L_{it}^{\beta_l} R_{it}^{\beta_r} \left[\int_0^{N(d_{it})} Z(g)^{\frac{\theta-1}{\theta}} dg \right]^{\frac{\beta_z \theta}{\theta-1}} \tag{1}$$

The term ω_{it} refers to an exogeneous productivity shock that is serially-correlated, $\theta > 1$ represents elasticity of substitution between any two material inputs, and $N(d_{it})$ denotes the range of intermediate inputs needed in the production that can be obtained from home country $N_{h,t}$ or from the world market $N_{f,t}$. The decision on intermediate input is a discrete choice function, denoted by $N(d_{it}) = (1 - d_{it})N_{h,t} + d_{it}N_{f,t}, d_{it} \in \{0, 1\}$, with 1 indicates foreign-sourced input and 0 domestically-sourced input.

At the equilibrium, all intermediate goods are symmetrically produced at level $\overline{z}$. Hence, substituting $z(g) = \overline{z}$ into Eq. 1 leads to:

$$Y_{it} = e^{\omega_{it}} N(d_{it})^{\frac{\beta_z}{\theta-1}} K_{it}^{\beta_k} L_{it}^{\beta_l} R_{it}^{\beta_r} Z_{it}^{\beta_z} \tag{2}$$

where $Z_{it} = N(d_{it})\overline{z}$. The TFP is defined as $A_{it} = \frac{Y_{it}}{K_{it}^{\beta_k} L_{it}^{\beta_l} R_{it}^{\beta_r} Z_{it}^{\beta_z}}$. Then, from Eq. 2, we get:

$$\ln A(d_{it}, \omega) = \frac{\beta_z}{\theta - 1} \ln(N(d_{it})) + \omega_{it} \tag{3}$$

Equation 3 indicates that productivity is positively related to the range of intermediate inputs utilised in production. Firms importing intermediate inputs from abroad can choose from a larger variety of intermediate inputs and thus have higher productivity than those using domestic intermediate inputs only. In this regard, importing inputs may affect the TFP due to technological and quality factors embedded in the imported inputs (Bas & Strauss-Kahn, 6).

To see whether imported inputs improve firms' productivity, we follow the approach of Levinsohn and Petrin (6), which is an extension of Olley and Pakes (6)—henceforth LP and OP, respectively. The LP method controls for the simultaneity bias in the production function that may arise from input variables and unobserved productivity shocks. Firm-specific productivity is known by the firm but not by the econometrician and the firm responds to expected productivity shocks by adjusting its inputs. This method also reduces the selection bias in which the unproductive firms are likely to leave the industry and be replaced by firms that are more productive. The LP method is preferable to the OP method due to data reason. The OP method relies on investment data as the proxy for the unobservable shocks. The investment proxy is only valid for firms that report non-zero investment; alas, many datasets do not report investment data. The LP method, on the other hand, uses material or energy inputs as proxies, and these variables are available in most datasets, reducing the need for truncation.

Another potential problem in the TFP estimation is that the imported input decision can be correlated with other inputs; thus, omitting the import variable in the estimation could yield inconsistent input coefficients and productivity estimates. Incorporating imported input variables should reduce this bias (De Loecker, 6; Kasahara & Rodrigue, 6; Bas & Strauss-Kahn, 6). Therefore, we modify the LP method by including import variable in the TFP estimation. With a Cobb–Douglas production function, we rewrite Eq. 2 into:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_r r_{it} + \beta_z z_{it} + \beta_d d_{it} + \omega_{it} + v_{it} \tag{4}$$

where lower-case variables denote logged values and d_{it} is the discrete choice of whether or not to import from abroad; ω_{it} captures productivity and v_{it} is the standard *i.i.d* error term capturing unanticipated shocks to production and measurement error. All variables in values are deflated to proxy for physical quantities. After estimating Eq. 4 and getting all coefficient of inputs, the TFP is estimated by using the procedures explained by De Loecker and Warzynski (6) and Mollisi and Rovigatti (6) with simplification as:

$$\hat{\omega}_{it} = \varphi_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_r r_{it} - \hat{\beta}_z z_{it} - \hat{\beta}_d d_{it}. \tag{5}$$

2.2 Export performance

Next, we connect the decision on intermediate inputs to export performance. Consider the profit maximisation problem of firm i: $\max \pi_{it} = r(y)_{it} - c(y)_{it}$, where r is revenue and c is cost, both depend on the quantity of production y_{it}. Noted that firm i might export part of its production in as much as y_{it}^{EX}; where $y_{it} = y_{it}^{EX} + y_{it}^{DOM}$. As noted in Eq. 1, the quantity of output produced y_{it} depends on the input choices, including intermediate inputs obtained from domestic producers $N_{h,t}$ and from import $N_{f,t}$. Each intermediate input is selected to maximise the firm's export profits; therefore, the profit is also a function of intermediate inputs, $\pi_{it} = f\{N(d_{it})\}$.

Input decision affects the cost of production, $c(y)_{it}$ in several ways. When the firm selects its combined inputs, the fixed and marginal costs to acquire the inputs determine the optimal input use. As discussed by Kasahara and Lapham (6) and Damijan et al. (6), the fixed costs of getting intermediate inputs could be significant, especially for the imported inputs.[6] The firm might face credit constraints that limit the amount of working capital available; thus, only more productive firms (or firms that can utilise the inputs efficiently) are able to import. This is also explained by Eq. 3 that connects import decision and productivity.

The marginal cost of obtaining an input depends on the price of the input as well as other variable costs. Given a certain level of quality required, a firm will choose the cheapest one from various options of a specific intermediate material either from domestic- or foreign markets. Even though imported input could be cheaper, firms need to consider additional variable costs before deciding to import. These costs may include import tariffs as well as the costs associated with real exchange rates. Any change in these factors may affect the decision to import the intermediate inputs. The firm could thus respond to the changes in these variable costs by adjusting its set of imported intermediate inputs or the levels of the imported inputs used in the production or both.

The decision on inputs could affect the revenue $r(y)_{it}$ via prices as well as via quantities demanded (Fan et al., 6). As imported inputs potentially have higher quality, the amount (and the variety) of imported intermediate inputs used in the production could improve the firms' total revenue. The firms' export revenue could also increase since specific export markets might demand a specific quality of final products. Additionally, the increase in imported intermediate inputs could influence the firm's output through the production function, as noted. The production technology could become more efficient due to an increased division of labour (Ethier, 6), or due to the superior quality of imported inputs relative to domestic inputs (Halpern et al., 6), or the combination of both.

In the era of globalisation where trade costs are getting lower, firms no longer have to focus only on domestic markets but now they have the incentive to serve foreign markets as well. In serving these different markets, the skills needed to navigate the abundant choice of intermediate inputs become more crucial. Access to intermediate inputs at free trade prices becomes a key determinant of export success. It is even more so, as firms get involved in production networks. The increasing degree of specialisation at country and firm level amplifies the need of intermediate inputs. As discussed in many literatures on global value chains (GVCs), as the global trade intensifies, cross-country transactions via both import on intermediate inputs and

[6] These fixed costs include sunk costs and per-period fixed costs. The former includes costs for establishing a network with a foreign supplier and for learning about government regulations, while the latter includes fixed costs per shipment that force firms to reduce the frequency of shipments but with a higher volume (Kasahara & Lapham 6; Kropf & Saure, 6).

exports also increases (Athukorala & Kohpaiboon, 6; Hummels et al., 6; Johnson & Noguera, 6). At the micro level, the proportion of manufacturing firms engaged in both importing and exporting activities also increases.

Since many firms do both import and export, there could be a two-way relation between the import of intermediate inputs and export performance. Aristei et al. (5) and Kasahara and Lapham (6) have discussed some possible mechanisms by which these two activities could be complementary and simultaneous—even though the direction is more obvious from import to export than the other way around. Assuming there are sunk costs for import and export, the most productive firms would self-select into two-way trade. Firms that are one-way traders might switch and become two-way traders if they can spread the sunk costs across the two activities. The cost of exporting (importing) can be reduced whenever the firm in question already carries out importing (exporting) activities. If a firm has been exposed to foreign markets by importing (exporting), its productivity could be further increased due to the learning mechanism which in turn affects its export (import) performance.

Our main interest is to see how imported intermediate inputs affect export performance. The basic empirical model follows a supply equation:

$$Export_{ijt} = \alpha + \beta Import_{ijt} + \gamma X_{ijt} + \varepsilon_{ijt} \tag{6}$$

where $Export_{ijt}$ is the export performance of firm i in industry j (at 5-digit International Standard Industrial Classification (ISIC)) in year t. The export performance is defined as the natural log of firm i' s total export value. The primary interest is thus the coefficient β. In this study we use two definitions of imported inputs, namely the natural log of total import value and the natural log of the number of imported country-product pair varieties. Several firm-level control variables are included in X_{ijt} such as the number of workers, the estimated TFP and the status of foreign ownership. The error term is defined as $\varepsilon_{ijt} = \delta_{ij} + \sigma_t + \rho_j + \epsilon_{ijt}$ with ϵ_{ijt} following an independent and identically distributed (i.i.d.) distribution with δ_{ij}, σ_t, and ρ_j represent firm-fixed effects, time-fixed effects, and industry-specific characteristics, respectively.[7]

Equation 6 can be estimated using an ordinary least squares (OLS) fixed-effects estimator if we believe the import variable is exogenous on export. However, as noted, some simultaneities between these two variables might take place. To overcome this possibility, we construct two exogenous variables that measure the relative costs of foreign inputs to instrument the import decision.

2.3 Instruments

The two instrumental variables used are inputs' import tariffs and inputs' import real exchange rates. Both instruments are weighted at the 5-digit ISIC industry-year level

[7] One might expect a lagged structure in this equation as imports might take time before it affects export. But due to data limitation (five years' observations), we do not employ lags in the model. Our IV strategy explained below should reduce the endogeneity problem between export and import.

to reduce the reverse causality problem between import at the firm-level and these instruments. Following Feng et al. (6), we identify the input import tariff $ImDuty_{jt}$ and import-weighted real exchange rate $ImRER_{jt}$ in industry j in year t, respectively, as follows:

$$ImDuty_{jt} = \sum_{p=1}^{P_j^M} \frac{\overline{IM}_{pj}}{\sum_{p=1}^{P_j^M} \overline{IM}_{pj}} \tau_{pt} \tag{7}$$

$$ImRER_{jt} = \sum_{c=1}^{C_j^M} \frac{\overline{IM}_{cj}}{\sum_{c=1}^{C_j^M} \overline{IM}_{cj}} RER_{ct} \tag{8}$$

where $\overline{IM}_{pj}$ is the value of imported input p needed in industry j, τ_{pt} is the aggregate tariff on product p in year t, $\overline{IM}_{cj}$ is the value of total imported input in industry j originating from country c, and RER_{ct} is the constructed real exchange rate between Indonesia and country c in year t.

As will be discussed in the data section, our period of observations covers only five years, namely from 2008 to 2012. Consequently, we cannot employ year-fixed effects in the IV model since it will absorb all time variation on the instruments. Therefore, we modify the basic model by changing the year-fixed effect term. As the observation period includes the crisis years of 2008 and 2009, we employ a crisis dummy equal to one if it is within the crisis years and zero otherwise. We expect this crisis dummy to play a similar role as the year-fixed effects do by absorbing most of the unobserved time variant confounding factors in the model. Equation 6 can thus be modified into:

$$Export_{ijt} = \alpha + \beta Import_{ijt} + \gamma X_{ijt} + \delta_{ij} + crisis_t + \rho_j + \epsilon_{ijt} \tag{9}$$

In addition to the control variables in X_{ijt}, some variables that affect the costs of exports are also included. They are output tariffs that Indonesian firms have to pay in export-destination markets and export-weighted real exchange rates, which are constructed as in Feng et al. (6). These two variables are also at the 5-digit ISIC industry-year level to reduce the possibility of reverse causality between exports and these variables. In particular, the output tariff measure is constructed as:

$$ExDuty_{jt} = \sum_{p=1}^{P_j^E} \sum_{c=1}^{C_j^E} \frac{\overline{EX}_{pcj}}{\sum_{p=1}^{P_j^E} \sum_{c=1}^{C_j^E} \overline{EX}_{pcj}} \tau_{pct} \tag{10}$$

where $\overline{EX}_{pcj}$ is the average export value during 2008–2012 of 6-digit product p exported by firms in the 5-digit ISIC industry j in the country c; and P_j^E and C_j^E are the sets of exported products and destination countries, respectively. The most favoured nation (MFN) tariffs imposed on product p by export destination country c in year t is denoted τ_{pct}. The export-weighted real exchange rate is thus defined as:

$$ExRER_{jt} = \sum_{c=1}^{C_j^E} \frac{\overline{EX}_{cj}}{\sum_{c=1}^{C_j^E} \overline{EX}_{cj}} RER_{ct} \tag{11}$$

where $\overline{EX}_{cj}$ is the average export value during 2008–2012 shipped by firms in industry j to country c.

3 Data

This study uses a unique, unbalanced panel dataset of Indonesian manufacturing firms from 2008 to 2012 compiled from different sources. The first one is the Industrial Statistics (*Statistik Industri*, SI) that is based on annual surveys conducted by Indonesia's Central Bureau of Statistics (*Badan Pusat Statistik*, BPS). Every year the survey covers firms employing 20 or more workers.[8] The data captures detailed information of each firm at the 5-digit level of the ISIC classification, such as inputs—capital stock, labour, material, and energy used in the production—outputs, and ownership.

The second source of data is from the Indonesian Customs Office that records detailed transactions of exports and imports of manufacturing firms.The import dataset contains information at the firm level about import sources, USD import values and import volumes in kilograms for each detailed HS 10-digit product.[9] The export dataset provides information about export destinations; USD export values, and the net weight of export volumes in kilograms for each detailed HS 10-digit product.

All these datasets are then merged using the firm identifier, leading to a rich dataset with detailed firm-level information as well as import and export activities. Since the matched dataset covers only manufacturing firms, therefore, it is assumed that all import transactions are for intermediate inputs for production.

To estimate the TFP, we use the whole sample from the Industrial Statistics. We use the wholesale price index (WPI) data, also published by BPS to deflate several variables.[10] Capital stock data could be problematic given there are many missing observations in various years. We drop firms with missing capital data for two consecutive years or more. We then apply interpolation if the missing data is only for one year.

For analysing the behaviour of exporting (and importing) firms, the main model uses only those firms that participate in export and/or import activities as recorded

[8] The survey is conducted at plant level. Some plants could be related to each other under a holding company. However, the information about this is untraceable. For simplicity, we use the term 'firm' for the rest of the paper.

[9] The standard HS data are expressed in 6-digit classifications, but the Indonesian government classifies import and export products up to a 10-digit HS.

[10] We thank [...] for sharing his aggregation of BPS' WPI from the published WPI code to 4-digit ISIC Revision 3.

Table 1 Exporting and importing firms. *Source*: Calculated from the Custom data

Year	Only exporter	Only importer	Exporter and importer	Total
2008	1087	549	742	2378
2009	1165	585	794	2544
2010	1134	667	837	2638
2011	1113	696	875	2684
2012	935	775	962	2672
All	5434	3272	4210	12,916

in the Custom data.[11] Table 1 shows the number of firms based on their trading activities, that are included in the main model. Some firms do only one-way trade activity, but others do both exporting and importing.[12]

To construct the instrumental variables as well as some control variables, we need additional data from other sources. We collect tariff data from the UNCTAD's Trade Analysis Information System (TRAINS) database and exchange rate data from the Penn World Table.[13] For $ExDuty_{jt}$ we collect detailed import applied Most Favourite Nation (MFN) tariffs at HS 6-digit in all countries and connect them with each export destination of Indonesia's 10-digit HS exported products.

As for $ImDuty_{jt}$ the procedure is more complicated. We use detailed Indonesian import tariffs at the HS 6-digit product classification, which is then matched with the HS 10-digit imported inputs data. We use the average applied preference tariffs instead of the applied MFN tariffs. This is because the applied MFN tariffs, for almost all of Indonesia's imported products, had not changed significantly during the observation period as Indonesia had passed the period of the liberalisation of MFN tariffs. Since we rely on the variations of the instrument, we instead use the variations of tariffs associated with preferential trade agreements (PTAs). During the period of observation, Indonesia increased its engagement with neighbouring countries by participating in bilateral or regional free trade agreements (FTAs).[14] Even though we cannot track which firms use which tariffs, the change in the preferential

[11] There is a possibility that firms do export or import indirectly. They trade through the trading companies and their activities are reported in the SI. However, we focus only on firms that trade directly, as the custom data only identifies manufacturing firms that do export or import directly. Due to this selection bias, we might underestimate the results. If so, the effects of imported intermediate inputs might, in reality, be higher.

[12] It is a bit puzzling that the largest group of firms falls into the 'only exporter' category. This implies that all their inputs are domestically sourced. Table 14 in the "OnlineAppendix" might explain this situation. As it turns out, the three largest observations of firms in the dataset indeed came from the food industry (ISIC 15), the furniture industry (ISIC 36) and the manufacture of rubber and plastic (ISIC 25).

[13] The RER construction follows Feenstra et al. (6).

[14] Particularly the Indonesia–Japan Economic Partnership Agreement (IJEPA) in 2007 and the ASEAN China Free Trade Agreement (ACFTA) in 2010.

Table 2 Top 10 source countries for Indonesian firms' imports of intermediate goods, 2012. *Source*: Calculated from the Custom data

	Rank by			Number of importers		Value of imports	
	Frequency	Firms	Value	Firms	% of total	Imports (million USD)	% of total
Japan	1	2	1	893	46.7	4410	15.3
China	2	1	2	1391	72.8	3980	13.8
South Korea	3	4	4	754	39.4	1590	5.5
Taiwan	4	3	8	861	45.0	959	3.3
Singapore	5	6	6	669	35.0	1130	3.9
Germany	6	9	9	577	30.2	740	2.6
Hong Kong	7	10	10	366	19.1	462	1.6
USA	8	8	5	619	32.4	1390	4.8
Malaysia	9	5	7	685	35.8	1030	3.6
Thailand	10	7	3	625	32.7	2020	7.0

tariffs schedule can be assumed to affect the firms' participation in international trade as tariffs affect the cost of imports.[15],[16]

Table 2 shows the top 10 countries from which Indonesian firms imported their intermediate goods in 2012. China, Japan and South Korea are the three largest sources of imports that cumulatively account for 34.6% of imports of intermediate goods. The ASEAN countries, namely Malaysia, Singapore and Thailand are also large sources of imports; and together with the former group—as well as other ASEAN countries—they account for more than half of the imports of intermediate goods. Indonesia has PTAs with all these countries. Furthermore, even though there are no preferential tariffs, Indonesia also imports a large number of intermediate goods from Germany (and other European countries), Hong Kong, Taiwan and the USA. These whole groups have been sourced for almost 80% of Indonesia's imports of intermediate products. Therefore, to construct the instrument we use the average applied preferential tariffs of each of the HS 6-digit products from these countries. As explained in the methodology section, these tariffs are then aggregated at a 5-digit ISIC industry classification. For comparison, Table 15 in the "Online Appendix" provides the top 10 export destinations of Indonesian manufacturing products in 2012.

[15] Note, however, that the utilisation rates of FTAs by Indonesian firms are relatively small albeit increasing over the years (Anas & Narjoko 3). Among ASEAN FTAs, the highest utilisation rate for exports is the concession with China under the ACFTA (around 70 percent in 2015) and among ASEAN members (around 60 percent in 2015). For imports, the IJEPA and the ASEAN Trade in Goods Agreement (ATIGA) have the highest utilisation at around 24 percent in 2016.

[16] It is possible that one country's import tariff reforms coincide with its export tariff reforms, such as when it joins the WTO. As our dataset spans from 2008 to 2012, and most of Indonesia's trade partners accessed the WTO prior to that period, the validity of our instruments should not be affected.

Table 3 Summary statistics

Variable	Obs	Mean	SD	Min	Max
Import-weighted tariffs	12,916	1.99	1.95	0	18.63
Import-weighted RER	12,916	98.96	9.20	72.08	184.24
Export-weighted tariffs	12,916	8.80	21.74	0	587.33
Export-weighted RER	12,916	100.79	7.98	69.76	252.20
Ln(Export_value)	12,916	10.24	6.41	0	21.78
Ln(Import_value)	12,916	8.15	7.17	0	21.26
Ln(Import_varieties)	12,916	1.71	1.77	0	7.09
Import varieties	12,916	26.06	64.81	0	1204.00
Number of workers	12,916	486.90	1315.48	20.00	38,343.00
Foreign-owned status	12,916	0.32	0.47	0	1.00
Ln(TFP)	12,916	1.23	0.16	−0.34	1.62

Variables in natural logarithmic form are calculated by adding one for zero value to reduce data truncation

It is possible that the preferential tariffs data embed some problems. If trade policies across industries are influenced by industry lobbying and expected exports, there could be a serious correlation issue between tariff changes and industry specific characteristics. To hedge against this problem, we follow a strategy designed by Bas and Strauss-Kahn (6) that examines the correlation of tariff changes with initial industry performance. We regress the changes in input tariffs on a number of industry characteristics computed as the average firm's initial characteristics in the initial year. They are TFP, employment, wages and exports at the industry level. Table 16 in the "Online Appendix" provides the results and shows that there is no statistical correlation between input tariffs and industry characteristics.

To construct the import- (and export-) weighted real exchange rates (RER), we utilise the longitudinal data on countries that is available from the Penn World Table 9.0 (Feenstra et al., 6). The dataset provides information on the bilateral nominal exchange rate between the currency of any particular country and USDs over the years. We transform this information into an index of bilateral exchange rates with Indonesian Rupiah (IDR). The dataset also includes information on the domestic prices in every country over the years. We transform the prices data into indexes (2008 = 100) and express them as units of Indonesian baskets per basket of a specific foreign country. We then construct the import- (and export-) weighted real exchange rates by incorporating the weighting procedures explained in the methodology section. Table 17 in the "OnlineAppendix" provides detailed information on the import- (and export-) weighted tariffs and exchanges rates that are aggregated into a 2-digit ISIC. Table 3 shows the descriptive statistics for all the variables used in the main model. Table 18 in the "Online Appendix" gives more detailed information about the imported input variation across the 2-digit ISIC sectors.

Table 4 TFP estimation

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Production Output)$_{it}$					
Ln(Labour)$_{it}$	0.289***	0.286***	0.285***	0.286***	0.285***	0.286***
	(0.00520)	(0.0101)	(0.0147)	(0.0120)	(0.0133)	(0.00727)
Ln(Material)$_{it}$	0.937***	0.936***	0.937***	0.937***	0.936***	0.936***
	(0.00152)	(0.00341)	(0.00352)	(0.00170)	(0.000560)	(0.00307)
Ln(Capital)$_{it}$	0.0064***	0.00553***	0.0040***	0.00399***	0.00432***	0.00521***
	(0.00083)	(0.00137)	(0.00100)	(0.00102)	(0.00139)	(0.00166)
Import dummy$_{it}$		0.0621***				
		(0.00418)				
Ln(Import variety) $_{it}$			0.029***			
			(0.00099)			
Ln(Import value from Developed countries)$_{it}$				0.00245***		
				(0.000763)		
Ln(import value from developing countries)$_{it}$				0.00694		
				(0.00649)		
Import (dummy—East Asia region)$_{it}$					0.0942***	
					(9.13e-05)	
Import (dummy—non East Asia region)$_{it}$					0.0016***	
					(0.000425)	

Table 4 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(Production Output)$_{it}$					
Import (dummy—East Asia region—GPS sectors)$_{it}$						0.343***
						(0.00309)
Import (dummy—East Asia region—non GPS sectors)$_{it}$						0.0387***
						(0.00184)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	112,017	112,017	112,017	112,017	112,017	112,017
Number of groups	27,078	27,078	27,078	27,078	27,078	27,078

The TFP estimations use the Levinsohn–Petrin method. Standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

4 Results

4.1 Imported inputs and productivity

Table 4 shows the estimation results of production function in Eq. 4 using the LP method. Column 1 presents the baseline results from the standard model. Columns 2–6 show the results when different definitions of variables of imported intermediate inputs are included in the model. In line with other studies (Amiti & Konings, 2; Bas & Strauss-Kahn, 6; Halpern et al., 6; Kasahara & Rodrigue, 6), we find that importing some of the intermediate inputs for production increases productivity. From Column 2, we can infer that the decision to import some intermediate inputs can improve productivity by 0.06%. Meanwhile, a 1% increase in the number of varieties of imported inputs improves productivity by 0.03% (Column 3). Using French data, Bas and Strauss-Kahn (6) find that increasing the variety of imported inputs by 1% could increase productivity by 0.1%. There are two possible reasons why the impact in Indonesia is not as high as that in France. One could be related to the type of products they produce and the source of inputs they use. French manufacturers are more likely to produce more advanced products with higher technology, while Indonesian manufactured productions are mainly still in the low-skilled and labour-intensive sectors. Secondly, French manufacturers are more likely to import inputs from neighbouring countries in the EU, who provide advanced technology products, while imported inputs for Indonesian firms are sourced mainly from economies in the East Asia region, with more varying industrial advancement.

Next, we examine the source of imported inputs to identify the possible channels of improved productivity. The coefficients of imported inputs from developed and developing countries are positive but are only significant for the case of imports from developed countries (Column 4). The technology (and quality) effects embedded in the inputs from developed countries could be the source of augmented productivity. Column 5 shows the results when the sources of inputs are divided into regions. Importing intermediate inputs from any region improves productivity but importing from neighbouring countries in the East Asian region have higher effects. This may imply the effects of regional value chains. In Column (6), this factor is further scrutinised. When the industry of a firm is classified as being in the global production sharing (GPS) sectors, the effect of imported inputs on the productivity of Indonesian firms turns out to be much higher.[17] Together with the regional effect as noted (Column 5) this might imply that Indonesian firms have benefitted from the growing production network in the region by way of importing from this network to increase their productivity.

[17] We use the classification of GPS industries by Athukorala & Kohpaiboon (6). See Table 19 in the "Online Appendix".

Table 5 The impact of imported input varieties on export

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: $Ln(Export value)_{ijt}$						First stage	
	FE	FE	FE	IV FE	FE	IV FE	$Ln(Import variety)_{ijt}$	
$Ln(Import varieties)_{ijt}$	0.151***	0.085**	0.090**	1.765***	0.088**	1.796***		
	(0.039)	(0.039)	(0.039)	(0.497)	(0.039)	(0.490)		
$ExRER_{jt}$	0.003	−0.000	−0.005	−0.005	−0.005	−0.005	0.000	0.000
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.001)	(0.001)
$ExDuty_{jt}$	0.000	−0.000	0.000	−0.000	0.000	−0.000	0.000	0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)
Crisis dummy			−0.339***	−0.043	−0.338***	−0.037	−0.167***	−0.166***
			(0.035)	(0.093)	(0.035)	(0.092)	(0.013)	(0.013)
TFP_{ijt}					−0.077	−0.213		0.081
					(0.187)	(0.221)		(0.065)
$Size_{ijt}$					0.097**	0.048		0.034**
					(0.045)	(0.051)		(0.014)
FDI_{ijt}					0.062	0.053		0.008
					(0.109)	(0.125)		(0.037)
$ImDuty_{jt}$							−0.022***	−0.022***
							(0.005)	(0.005)
$ImRER_{jt}$							−0.003***	−0.003***
							(0.001)	(0.001)
Constant	9.668***	9.532***	10.652***		10.178***			
	(0.550)	(0.605)	(0.577)		(0.680)			
Observations	12,523	12,523	12,523	12,523	12,523	12,523	12,523	12,523
Number of firms	2901	2901	2901	2901	2901	2901	2901	2901
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Ln(Export value)$_{ijt}$						First stage	
	FE	FE	FE	IV FE	FE	IV FE	Ln(Import variety)$_{ijt}$	
Year fixed effects	No	Yes	No	No	No	No	No	No
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV statistics								
Hansen J-statistic				0.15		0.15		
p-value of Hansen J-statistic				0.70		0.70		
Endogeneity Tests				14.72		15.90		
LM test statistic				48.04		49.51		
F-statistic Kleibergen-Paap				24.27		25.01		
Stock-Yogo 10%				19.93		19.93		
Stock-Yogo 15%				11.59		11.59		
Stock-Yogo 20%				8.75		8.75		
Stock-Yogo 25%				7.25		7.25		

The TFP is from an omega prediction resulted from a specification in Column 2 in Table 4. Industry-fixed effects are in 2-digit ISIC. Robust standard errors in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$. There are 393 singleton observations

Table 6 The impact of the increase of intermediate input value on export

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Ln(Export value)$_{ijt}$						First stage	
	FE	FE	FE	IV FE	FE	IV FE	Ln(Import value)$_{ijt}$	
Ln(Import value)$_{ijt}$	−0.004	−0.023*	−0.022*	0.450***	−0.022*	0.461***		
	(0.012)	(0.013)	(0.013)	(0.127)	(0.013)	(0.127)		
ExRER$_{jt}$	0.004	−0.000	−0.006	−0.003	−0.005	−0.003	−0.001	−0.001
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)
ExDuty$_{jt}$	0.000	−0.000	0.000	0.000	0.000	0.000	−0.000	−0.000
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Crisis dummy			−0.369***	−0.061	−0.368***	−0.053	−0.617***	−0.616***
			(0.035)	(0.088)	(0.035)	(0.088)	(0.051)	(0.051)
TFP$_{ijt}$					−0.061	−0.252		0.401
					(0.186)	(0.228)		(0.249)
Size$_{ijt}$					0.101**	0.066		0.096*
					(0.045)	(0.051)		(0.051)
FDI$_{ijt}$					0.064	0.034		0.071
					(0.109)	(0.119)		(0.134)
ImDuty$_{jt}$							−0.084***	−0.085***
							(0.019)	(0.019)
ImRER$_{jt}$							−0.011***	−0.012***
							(0.003)	(0.003)
Constant	9.975***	9.903***	11.087***		10.569***			
	(0.560)	(0.617)	(0.591)		(0.692)			
Observations	12,523	12,523	12,523	12,523	12,523	12,523	12,523	12,523
Number of firms	2901	2901	2901	2901	2901	2901	2901	2901
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Ln(Export value)$_{ijt}$						First stage	
	FE	FE	FE	IV FE	FE	IV FE	Ln(Import value)$_{ijt}$	
Year fixed effects	No	Yes	No	No	No	No	No	No
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First stage IV statistics								
Hansen J-statistic				0.11		0.10		
p-value of Hansen J-statistic				0.74		0.75		
Endogeneity Tests				18.24		19.61		
LM test statistic				55.34		56.15		
F-statistic Kleibergen-Paap				27.76		28.16		
Stock-Yogo 10%				19.93		19.93		
Stock-Yogo 15%				11.59		11.59		
Stock-Yogo 20%				8.75		8.75		
Stock-Yogo 25%				7.25		7.25		

TFP is from omega prediction resulted from specification in Column 2 in Table 4. Industry fixed effects are in 2-digit ISIC. Robust standard errors in parentheses
***$p<0.01$, **$p<0.05$, *$p<0.1$. There are 393 singleton observations

4.2 Imported inputs and export performance

4.2.1 Input varieties and input values

Tables 5 and 6 provide the estimated impact of importing intermediate inputs on exports. Table 5 uses variety of the import as the explanatory variable, while Table 6 uses import value. We start with Table 5. First, we apply a standard fixed-effects technique. Columns 1–3 show the results with different specifications, indicating positive and significant association of importing intermediate inputs with exports. As expected, the year-fixed effect absorbs the impact of year-specific unobserved variables, so the magnitude of the variable of interest, ln(import varieties) is smaller in Column 2 than in Column 1.

As noted, we can no longer use the year-fixed effect in the IV estimations, so we replace it with a crisis dummy. Columns 4 and 6 show the results from the IV estimation, their corresponding first-stage results being Columns 7 and 8, respectively. For comparison, we also run the standard FE estimation with crisis dummy instead of year-fixed effect, i.e., Columns 3 and 5, respectively. The coefficient of import varieties in Column 3 is almost the same as that in Column 2, albeit a bit higher. This confirms that the crisis dummy could absorb most of the omitted time bias although not completely. With this caveat, the rest of the identification strategies rely on the crisis dummy to absorb the bias related to the time effects.

The size of the coefficient in the IV FE estimation is much larger than in the fixed effect estimation (Column 4 and 6 compared to column 3 and 5). One possible explanation is that the fixed effect estimation is skewed due to the correlation between variables of interest and error terms. An omitted variable issue could result in a downward bias of the fixed effect estimates. Another possibility is that the IV FE estimates the local average treatment effect (LATE) of firms affected by the instruments, whereas the FE estimates the overall population's average treatment effect (ATE).

Column 4 shows that a 1% increase in imported input varieties escalates the export value by 1.8%. Incorporating other firm-level variables, namely TFP, size and foreign ownership, does not notably alter the magnitude of the import coefficient (Column 6). This is consistent with the fixed-effects identification (Column 5). Note that for all specifications in Columns 1–6, the control variables are not (or they are less) significant with relatively small magnitudes. Most of variations in firm-level variables might have already been absorbed by the firm-fixed effects, so these control variables become insignificant. Interestingly, export-weighted tariffs and RER variables are not significant. This indicates that changes in export costs do not affect firm-level exports. It is consistent with the fact that Indonesian firms are generally price takers and any changes in variable costs of exporting might not change the level of exports by firms that have already been exporting.

The IV results are supported by first stage statistics that confirm the acceptability of selected instruments; that is the F statistics are larger than 10%; the Stock-Yogo critical value. Additionally, the Hansen tests infer that the over-identification restrictions are valid. Columns 7 and 8 show that both instruments have negative and significant coefficients on import varieties. The import-weighted tariff variable has the expected impact on import variety: imports increase as the import tariff declines. On the other hand, the sign of the import-weighted exchange rate indicates that as the rupiah appreciates in real terms against the currencies of input-supplying partners, there is a decrease in the import of intermediate inputs of manufacturing products. This might be due to the way we construct this variable. Recall that the variable of weighted exchange rates only takes the import of intermediate inputs into account while ignoring export dynamics. Feng et al. (6) find a similar result, that is, a negative relationship between domestic currency appreciations and imports of intermediate inputs.

Table 6 shows the results when the variable of interest is import value, instead of import varieties. The impact of an increase in imported input values on export values is not clear cut. The fixed-effects model shows a significant negative association of import on export, with very small magnitudes and at 10% significance only. The IV strategy provides more reasonable results and shows a positive and significant effect of increasing imported input values on exports. Columns 4 and 6 indicate that a 1% increase in imported input value increases exports by 0.4–0.5%. Consistent with the results in Table 5, the decline in import tariffs increases the imports of intermediate inputs; and local currency appreciation reduces the imports of manufacturing inputs.

Comparing the results from Tables 5 and 6 can enrich our understanding of the impact of imported inputs on export. As noted, import varieties have become an important source of gains (Broda & Weinstein, 6). The access to a wider range of import varieties helps increase export performance. Some types of intermediate inputs might not be produced locally, therefore importing them should be beneficial and improve the firm's ability to produce and export. Additionally, broader options of varieties from various countries could help increase the firm's efficiency in producing exported products. Our study confirms this hypothesis. While a 1% increase in the value of imported inputs increases exports by 0.5%, a 1% increase in the number of varieties of the imported inputs increases exports by 1.8%. This might imply that the main source of benefits from importing, for a developing country like Indonesia, is through access to a broader range of options of inputs rather than just through increasing import values.

To support this assertion, we investigate the dataset more closely. During the period of observations, on average, firms could increase the number of country sources of imports in terms of 10-digit HS products (recall Table 18 in the "Online Appendix"). There are at least three possible reasons for this. First, firms would like to source from countries that offer lower prices (price-substitute effects). Second, firms tend to increase the quality of goods produced by sourcing the material inputs from countries that offer better inputs (often associated with inputs that have higher prices or inputs from more advanced countries). Third, firms prefer to combine inputs from several countries for price and quality reasons or to produce more product varieties in its own production lines. Table 19 in the "Online Appendix" illustrates this with the case of one particular firm in the dataset, showing its sourcing strategy. Each year, this firm, sources a type of product (HS 10 digit: 3919109000) from more than 10 countries, with different volumes and price combinations. Over the years, we can see that the firm tends to source a large amount of the product from the country offering the cheapest input, yet it still maintains inputs sourced

Table 7 Foreign-owned firms and domestic firms

Second stages IV	(1) Foreign-owned firms	(2)	(3) Fully domestic-owned firms	(4)
	Dependent variable: Ln(Export value)$_{ijt}$			
Ln(Import variety)$_{ijt}$	1.453**		2.225***	
	(0.598)		(0.827)	
Ln(Import value)$_{ijt}$		0.412**		0.509***
		(0.171)		(0.190)
Firm fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
Crisis dummy	Yes	Yes	Yes	Yes
Observations	3998	3998	8324	8324
Number of Firms	942	2026	942	2026
p-value of Hansen J statistic	0.619	0.579	0.955	0.833
F statistic Kleibergen-Paap	8.864	10.09	13.393	15.812
First Stages	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$
Ln(ImDuty)$_{jt}$	−0.030**	−0.100**	−0.015***	−0.071***
	(0.012)	(0.039)	(0.006)	(0.022)
Ln(ImRER)$_{jt}$	−0.003*	−0.012**	−0.003***	−0.011***
	(0.002)	(0.006)	(0.001)	(0.004)

Industry fixed effects is in 2-digit ISIC. Robust standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

from other countries albeit with more expensive prices. Elsewhere in the dataset, we find that many firms increased the number of their product varieties (again, in terms of 10-digit HS products) over time, as Table 18 in the "Online Appendix" shows. This may reflect that the firms acquired more access to new product varieties (new HS categories were introduced) or the firms would simply like to increase their own product varieties. All these possible reasons are likely to be more pronounced for exporting firms since they need to be competitive in the export market by offering cheaper prices with higher qualities. When they are trying to access more markets, they are more likely to produce more differentiated products to fulfil different tastes or quality requirements.

4.2.2 Foreign-owned firms and GPS-sector firms

The relation between imported inputs and exports might not be as clear for foreign-owned firms and those participating in global production networks. Often, the lead

Table 8 Firms in GPS and non-GPS sectors

Second stages IV	(1) GPS sectors	(2)	(3) Non-GPS sectors	(4)
	Dependent variable: Ln(Export value)$_{ijt}$			
Ln(Import varieties)$_{ijt}$	2.869		1.703***	
	(2.695)		(0.470)	
Ln(Import value)$_{ijt}$		0.623		0.435***
		(0.548)		(0.121)
Firm-fixed effects	Yes	Yes	Yes	Yes
Industry-fixed effects	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
Crisis dummy	Yes	Yes	Yes	Yes
Observations	1869	1869	10,576	10,576
Number of Firms	437	437	2497	2497
p-value of Hansen J statistic	0.872	0.986	0.693	0.871
F statistic Kleibergen-Paap	1.557	2.647	23.641	26.039
First stages	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$
Ln(ImDuty)$_{jt}$	−0.019	−0.103*	−0.023***	−0.082***
	(0.017)	(0.059)	(0.006)	(0.020)
Ln(ImRER)$_{jt}$	−0.001	−0.004	−0.003***	−0.014***
	(0.002)	(0.008)	(0.001)	(0.004)

Industry-fixed effects are in 2-digit ISIC. Robust standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

company at the headquarter country gives specific directions, some in time-based contracts, related to import–export decision to its subsidiary or partner firms in other countries. Many multinational firms in Indonesia have their headquarter office in Japan, Korea, the USA and other developed countries.

To explore this, we identify firms that are part of the GPS sector, using the definition from Athukorala and Kohpaiboon (6) (see the list on Table 20 in the "Online Appendix"). Table 7 provides the results if firms are separated into foreign-owned firms and domestic firms, while Table 8 differentiates the subsamples into firms in GPS and non-GPS sectors. The results show that the impact of imported inputs on exports is higher and more significant for fully domestic-owned firms than for foreign firms. This might indicate that among the input-importing firms in Indonesia, the domestic firms are more export-oriented whereas the foreign-owned firms focus more on taking advantage of the Indonesian market. Furthermore, such impact is significant for firms in non-GPS sectors but not so for those in GPS sectors. There

Table 9 Firms in resource-based sectors and non-resource-based sectors

Second Stages IV	(1)	(2)	(3)	(4)
	Resource-based sectors		Non-resource-based sectors	
	Dependent variable: Ln(Export value)$_{ijt}$			
Ln(Import varieties)$_{ijt}$	0.910		1.777***	
	(1.374)		(0.492)	
Ln(Import value)$_{ijt}$		0.188		0.521***
		(0.228)		(0.150)
Firm-fixed effects	Yes	Yes	Yes	Yes
Industry-fixed effects	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
Crisis dummy	Yes	Yes	Yes	Yes
Observations	3850	3850	8537	8537
Number of Firms	930	930	2010	2010
p-value of Hansen J statistic	0.646	0.950	0.574	0.627
F statistic Kleibergen-Paap	3.006	6.533	23.748	21.553
First Stages	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$	Ln(Import variety)$_{ijt}$	Ln(Import value)$_{ijt}$
Ln(ImDuty)$_{jt}$	0.007	−0.034	−0.028***	−0.094***
	(0.010)	(0.044)	(0.006)	(0.022)
Ln(ImRER)$_{jt}$	−0.003**	−0.014**	−0.003***	−0.012***
	(0.001)	(0.007)	(0.001)	(0.004)

Industry-fixed effects are in 2-digit ISIC. Robust standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

are two possible reasons for this. First, the lead firm at the headquarter offices may have given specific direction regarding import–export decisions to their subsidiary firms (i.e., those in GPS-sector). Second, firms in production sharing network may already have time-based contracts regarding import–export activities. These findings might also reflect an asymmetry in the level of engagement of Indonesian firms in global production network. As noted in Sect. 4.1, imports of intermediate goods increase productivity of Indonesian firms in GPS sectors more than those in non-GPS sectors, and the productivity is higher when imports originate from East Asian region (i.e., a regional production network) than from elsewhere; yet, when it comes to exports, it is the firms in non-GPS sectors that seem to benefit more from imports.

4.2.3 Resource-based- and non-resource-based sector firms

Indonesia produces various kinds of primary goods, including minerals as well as forestry products, which are the main inputs for firms in the resource-based manufacturing sectors. Therefore, we expect that these industries obtain the inputs mainly from the domestic market. To test this, we divide the firms based on resource-based sectors and non-resource-based sectors (see Table 21 in the "Online Appendix" for the classification). The results are shown in Table 9. As expected, the impact of imported inputs on exports in resource-based industries is not significant, while in non-resource sectors it is positive.

4.2.4 Technology and quality differences

To examine the mechanism by which imported intermediate inputs affect exports, we conduct further tests. The data on the source of imports is connected with the data on export destinations. Countries are grouped based on their level of development (UN classification) as well as on their region (see Table 22 in the "Online Appendix").[18]

Previous studies argue that technology and the quality embedded in the imported inputs are the reason why a firm's performance increases as it imports. In this study we examine this potential channel by grouping the import sources into developed and developing countries. Importing inputs from more technologically advanced countries is expected to have a higher effect on exports.

Furthermore, as discussed in any standard gravity model of trade, the geographical distance is an important factor that determines trade. This is especially relevant in the context of regional value chains. Manufacturing firms in a certain country intensify their trade with firms in neighbouring countries, either to supply inputs or to export their products—or both. We investigate this potential channel by classifying countries based on regions: East Asian region and non-East Asian region.

Tables 10 and 11 provide the results. Each table involves 25 different empirical estimations that combine different source of imports and export destinations. We decompose the country sources of intermediate inputs and the export destinations to analyse the impact of imported inputs on exports. As expected, we find that the effect is larger for the case of importing from developed countries (see Panel 2 in Tables 10 and 11). Compared to the baseline in Panel 1, sourcing input varieties from more technologically advanced countries provide a higher impact at about 35% for total exports; 37% for exports to developed countries and 31% for exports to the East Asian Region. Moreover, compared to the baseline, getting more inputs, in terms of value, from developed countries, which are expected to provide higher quality intermediate inputs, increases the export revenue by more than 62%. This

[18] We follow the previous studies to decompose countries based on their level of development (Bas & Strauss-Kahn 6; Feng et al. 6). However, instead of G7 and non-G7 countries, we use the United Nations (UN) definition of developed and developing countries. Since Indonesia's main trade partners are from the East Asian region, we also differentiate countries based on their regions. This could reflect the gravity-distance effects of trade and could explain Indonesia's participation in a regional value chain.

Table 10 Heterogeneous impact of the increase of import varieties on export by different combination of source–destination groups of countries

Variable of interest sources: Ln(Import variety)$_{ijt}$		(1)	(2)	(3)	(4)	(5)
		Outcome variable: Destination: Ln(Export value)$_{ijt}$				
		Total	Developed countries	Developing countries	East Asia regions	Non East Asia regions
(1)	Total	1.796***	1.332**	3.018***	3.764***	0.708
		(0.490)	(0.571)	(0.769)	(0.836)	(0.587)
	p-value of Hansen J statistic	0.70	0.96	0.17	0.10	0.21
	F statistic Kleibergen-Paap	25.01	25.01	25.01	25.01	25.01
(2)	Developed countries	2.424***	1.823**	3.974***	4.949***	0.852
		(0.710)	(0.798)	(1.117)	(1.241)	(0.803)
	p-value of Hansen J statistic	0.46	0.87	0.08	0.04	0.17
	F statistic Kleibergen-Paap	16.72	16.72	16.72	16.72	16.72
(3)	Developing countries	2.006***	1.487**	3.374***	4.209***	0.793
		(0.555)	(0.644)	(0.870)	(0.954)	(0.657)
	p-value of Hansen J statistic	0.95	0.18	0.11	0.21	0.71
	F statistic Kleibergen-Paap	22.44	22.44	22.44	22.44	22.44
(4)	East Asia regions	1.802***	1.332**	3.042***	3.795***	0.725
		(0.490)	(0.572)	(0.767)	(0.834)	(0.589)
	p-value of Hansen J statistic	0.76	0.92	0.20	0.12	0.21
	F statistic Kleibergen-Paap	25.92	25.92	25.92	25.92	25.92
(5)	Non-East Asia regions	3.291***	2.461**	5.449***	6.790***	1.214
		(1.041)	(1.117)	(1.653)	(1.895)	(1.097)
	p-value of Hansen J statistic	0.58	0.94	0.16	0.10	0.19
	F statistic Kleibergen-Paap	10.90	10.90	10.90	10.90	10.90

All specifications include firm-fixed effects and 2-digit ISIC industry-fixed effects. All specifications include the crisis dummy and controls at firm level: TFP, size, foreign-owned dummy and controls at industry level: export-weighted real exchange rates and average tariffs in the export markets. TFP is from omega prediction resulted from specification in Column (2) in Table 4. All specifications use instrument variable techniques and use instruments: import-weighted real exchange rates and import tariffs of intermediate inputs. The number of observations for all specifications is 12,523 with 2901 firms. There are 393 singleton observations. Robust standard errors in parentheses *$p<0.10$; **$p<0.05$; ***$p<0.01$

Table 11 Heterogeneous impact of the increase of import values on export by different combination of source–destination groups of countries

Variable of interest sources: Ln(Import value)$_{ijt}$		(1)	(2)	(3)	(4)	(5)
		Outcome variable: Destination: Ln(Export value)$_{ijt}$				
		Total	Developed countries	Developing countries	East Asia regions	Non East Asia regions
(1)	Total	0.461***	0.341**	0.777***	0.970***	0.185
		(0.127)	(0.147)	(0.197)	(0.213)	(0.151)
	p-value of Hansen J statistic	0.75	0.93	0.20	0.13	0.21
	F statistic Kleibergen-Paap	28.16	28.16	28.16	28.16	28.16
(2)	Developed countries	0.757***	0.553**	1.306***	1.631***	0.333
		(0.280)	(0.275)	(0.459)	(0.533)	(0.261)
	p-value of Hansen J statistic	0.97	0.79	0.56	0.52	0.28
	F statistic Kleibergen-Paap	6.36	6.36	6.36	6.36	6.36
(3)	Developing countries	0.477***	0.349**	0.819***	1.022***	0.206
		(0.136)	(0.155)	(0.212)	(0.233)	(0.158)
	p-value of Hansen J statistic	0.97	0.80	0.36	0.27	0.25
	F statistic Kleibergen-Paap	21.70	21.70	21.70	21.70	21.70
(4)	East Asia regions	0.480***	0.351**	0.827***	1.032***	0.209
		(0.137)	(0.156)	(0.213)	(0.234)	(0.159)
	p-value of Hansen J statistic	1.00	0.79	0.38	0.30	0.26
	F statistic Kleibergen-Paap	22.63	22.63	22.63	22.63	22.63
(5)	Non-East Asia regions	0.832***	0.622**	1.410***	1.765***	0.341
		(0.321)	(0.313)	(0.532)	(0.627)	(0.289)
	p-value of Hansen J statistic	0.86	0.94	0.43	0.38	0.24
	F statistic Kleibergen-Paap	5.04	5.04	5.04	5.04	5.04

All specifications include firm fixed effects and 2-digit ISIC industry fixed effects. All specifications include the crisis dummy and controls at firm level: TFP, size, foreign owned dummy and controls at industry level: export weighted real exchange rates and average tariffs in the export markets. TFP is from omega prediction resulted from specification in Column (2) in Table 4. All specifications use instrument variable technique and use instruments: import weighted real exchange rates and import tariffs of intermediate inputs. The number of observation for all specifications is 12,523 with 2901 firms. There are 393 singleton observations. Robust standard errors in parentheses $*p<0.10$; $**p<0.05$; $***p<0.01$

might be due to the higher quality of produced products (and hence higher price), that in turn is made possible by the higher quality of inputs. Based on these results, we can infer that the technology transfer through imported inputs from high-tech countries that are used in production could promote the export performance of the firms.

Grouping the countries based on regions reveals interesting findings. Specifications in Column 4 in Tables 10 and 11 provide evidence that the impact of imported inputs on exports in East Asian countries is more than double, compared to the baseline estimates in Column 1. The results are robust when we use different definitions of source of imports. There are two possible explanations. First, as the gravity-distance hypothesis predicts, the main destinations of Indonesian manufacturing exports are neighbouring countries; those in the East Asian region, as indicated by Tables 15 and 22 in the "Online Appendix". Exports to East Asia exceeded 50% of the total manufacturing exports in 2012. This statistic implies that there is an intensive trade engagement of Indonesian firms with firms in neighbouring countries. Second, this might also indicate that to export to countries in the East Asian region, firms need to obtain more inputs by sourcing them from abroad. Thus, importing intermediate inputs increases the firm's capability to access larger markets in the East Asian region. This suggests that imported inputs help Indonesian firms to export to regional markets.

Another interesting finding is that imports from non-East Asia give higher effects on export performance (Panel 5 of Tables 10 and 11). This is expected because the non-East Asian group contains most of the developed countries. Furthermore, as Table 23 in the "Online Appendix" shows, imports from non-East Asia are mainly from non-GPS sectors, such as food products and beverages (ISIC 15), textiles and garments (ISIC 17 and 18), as well as furniture and other manufacturers (ISIC 36). Indonesia also exports large numbers of products from these industries, so importing some inputs from foreign countries should positively affect the export performance of these sectors. However, the F-statistics of these specifications are relatively small, indicating weak instruments (that is, smaller than 15% of the Stock-Yogo critical value for specifications in Table 10 and less than 25% of the critical value for specifications in Table 11).

4.3 Robustness checks

Finally, we run several robustness checks with results shown in Table 12. We use different specifications of instruments in the IV model, and we vary the samples. First, we replace the preferential tariffs with MFN tariffs (Panel 1).[19] The results support the main finding, even though the magnitudes are smaller. However, in the first stage regression, it is revealed that the relation between tariffs and imports has an unexpected sign (see Table 24 in the "Online Appendix"). An increase in import

[19] Apart from tariffs, some other policies might also affect imports. They are duty drawbacks and non-tariffs barriers (NTB). However, due to the data availability, we cannot run specific tests to check for the impact of each of these other policies.

Table 12 Robustness checks

	Description	Impact of import variety	Impact of import value
(1)	Use MFN Tariffs	1.437***	0.368***
		(0.556)	(0.145)
	F statistic	19.595	18.829
(2)	Only use weighted tariffs instrument	1.701***	0.439***
		(0.522)	(0.134)
	F statistic	36.632	44.513
(3)	Only use weighted RER instrument	1.939***	0.490***
		(0.652)	(0.169)
	F statistic	35.636	33.558
(4)	Only include firms that do both export and import	3.149***	1.992***
		(0.964)	(0.715)
	F statistic	9.563	4.320
(5)	Exclude state-owned enterprises	1.822***	0.463***
		(0.500)	(0.128)
	F statistic	24.072	27.780
(6)	Exclude large firms (100 workers or more)	1.309	0.153
		(2.513)	(0.303)
	F statistic	1.186	5.949
(7)	Include crisis dummy	2.406***	0.718***
		(0.683)	(0.211)
	F statistic	14.423	13.071
(8)	Include crisis dummy x industry FE	1.972***	0.562***
		(0.629)	(0.176)
	F statistic	15.756	15.791
(9)	Use industry dummy 4-digit ISIC	1.697***	0.432***
		(0.475)	(0.122)
	F statistic	25.392	28.604
(10)	Include both imports from developed and developing countries in one equation	Devd: − 2.269	Devd: 0.296
		(7.730)	(9.584)
		Devg: 3.841	Devg: 0.291
		(6.323)	(6.000)
	F statistic	0.215	0.003
(11)	Include both imports from East Asian region and Non-East Asian region in one equation	EA: 3.568	EA: 0.441
		(7.577)	(1.908)
		Non-EA: − 3.272	Non-EA: 0.063
		(13.930)	(3.305)
	F statistic	0.094	0.026

The IV estimation using the *xtivreg2* estimator. All specifications include firm-fixed effects and 2-digit ISIC industry fixed effects, except in Panel 5. All specifications include the crisis dummy and controls at firm level: TFP, size, foreign-owned dummy and controls at industry level: export weighted real-exchange rates and average tariffs in the export markets. TFP is from an omega prediction using a *prodest* estimator which resulted from the specifications in Column 2, Table 4. Robust standard errors in parentheses *$p<0.10$; **$p<0.05$; ***$p<0.01$. F statistics are of Kleibergen-Paap tariffs increases imports. This might be due to the lack of variations in MFN-bound tariffs and applied MFN tariffs during the period of observations and/or the fact that the government can adjust (increase) an applied tariff as long as it is lower than the bound tariff (see Table 25 in the "Online Appendix"). Since firms still need inputs from abroad, an increase in MFN applied tariffs is still accompanied by an increase in the import of intermediate inputs.

Second, we use only one instrument in the model; it is either the weighted tariffs or the weighted RER (Panels 2 and 3). The results from both specifications confirm the main argument of the impact of imported inputs on exports. Third, we include only firms that are involved in both import and export activities (Panel 4). The results also support the main finding, but with larger magnitudes.

Next, we exclude state-owned enterprises and large firms as SOEs may have direct influence over trade policy, whereas large firms tend to engage more in international trade activities (Pane & Patunru, 6). While Panel 5 shows that excluding SOEs does not alter the findings,[20] Panel 6 shows that excluding large firms results in insignificant coefficients, confirming that it is the larger firms that are more benefited by imported inputs to increase their export performance.

Then, we include a different crisis dummy to allow the possibility that the effect the crisis took longer, in this case we define the dummy by years 2008–2010. Panels 7 and 8 again confirm the main findings.

Furthermore, we replace the industry dummy from a 2-digit ISIC with a 4-digit ISIC and the main argument holds (Panel 9). Finally, we run the specifications that include imported inputs in two countries' groups at the same time (Panels 10 and 11) and all specifications result in insignificant coefficients.

5 Concluding remarks

This paper has provided robust evidence of the important role of imported intermediate inputs in firm productivity and export performance. Using imported inputs in the production increases productivity; and the effect is larger if the inputs originate from developed countries, suggesting the better technology (and quality) embedded in the inputs. Furthermore, the effect is bigger when the import originates from firms in the East Asian region, and particularly from those engaged in GPS industries, implying a positive effect on productivity from participating in regional production networks.

Using an instrumental variable strategy, we find that the increased use of imported intermediate inputs due to exogenous changes in the costs of purchasing foreign inputs, as proxied by import-weighted tariffs and exchange rates, contributes positively to export growth. Importing more inputs, in terms of both value

[20] This is probably due to the small share of SOEs in the sample.

and varieties, affects export performance significantly. The effects of the latter on exports are much larger, implying that the main benefits of importing might come from access to broader alternatives of inputs. Further heterogeneity exploration reveals that import from developed countries provide higher contributions to export performance, which might imply a technology/quality channel.

What is the implication of this study on policy debate especially in developing countries? First, this study demonstrates that importing intermediate inputs contributes to productivity and export growth. Second, this study also shows that changes in import costs, namely tariffs and exchange rates, can affect imports of intermediate inputs, and thus productivity and export performance. Therefore, this study supports the argument to reduce restrictions on importing intermediate inputs in order to promote productivity and export growth.

Appendix

See Tables 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 and Fig. 1.

Table 13 Export, import of intermediate inputs and tariffs on manufacturing goods (2002 and 2015). *Source*: The trade data is from UNCOMTRADE database. Tariff data is from the TRAINS database. Both use standard region classifications from the databases

Region	Manufacturing Export (Billion USD)[a]		Import on Intermediate Inputs for Industry (Billion USD)[b]		Tariffs on intermediate inputs[b]	
	2002	2015	2002	2015	2002	2015
East Asia and Pacific	1329	4475	365	1293	4.5	4.2
Indonesia	40	105	12	55	5.1	5.2
South Asia	221	306	7	54	17.0	11.8
Middle East North Africa	238	291	40	88	11.6	6.1
Sub-Saharan Africa	66	95	10	34	10.3	8.3
Latin America and Caribbean	278	646	89	261	7.2	6.6
North America	555	1281	279	763	2.4	6.7
Eastern Europe and Central Asia	357	805	89	242	6.5	5.4
EU 25	1387	4705	683	2326	3.8	

[a]Data is constructed using ISIC Rev. 3: 2-digit sector 15–36

[b]Data is constructed using BEC classification: intermediate products for industry

Table 14 Imported input variation by sectors. *Source*: Calculated from the Custom data

2-Digit ISIC sector	No. of observations	Imported input variation		2-Digit ISIC sector	No. of observations	Imported input variation	
		Mean	Max			Mean	Max
15	2081	14.4	561	26	510	27.1	621
16	110	36.6	720	27	346	27.7	260
17	1120	20.6	524	28	840	30.6	1204
18	933	46.6	852	29	440	41.3	739
19	523	27.9	711	30	12	9.1	32
20	1111	4.7	119	31	295	42.9	588
21	423	22.9	478	32	301	49.3	713
22	134	10.1	95	33	62	83.3	649
23	54	7.9	92	34	416	57.8	588
24	1230	31.1	585	35	297	52.1	792
25	1341	16.6	366	36	1652	13.8	857

Table 15 Top 10 export destinations of Indonesia manufacturing products, 2012. *Source*: Calculated from the Custom data

	Rank by			Number of exporters		Value of Exports	
	Frequency	Firms	Value	Firms	% of total	Exports (million USD)	% of total
EU	1	1	2	968	45.68	5182	17.40
Japan	2	2	3	840	39.64	3702	12.43
USA	3	3	1	777	36.67	5441	18.27
Singapore	4	4	7	710	33.51	983	3.30
Malaysia	5	5	5	670	31.62	1226	4.12
China	6	6	4	663	31.29	2476	8.31
South Korea	7	7	8	561	26.47	842	2.83
Australia	8	8	9	539	25.44	555	1.87
Thailand	9	9	6	537	25.34	1171	3.93
Hong Kong	10	10	10	441	20.81	542	1.82

Table 16 Exogenous tariff changes to initial industry characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Changes in input tariffs (2008–2012)							
Employment (2008)	0.023				−0.047			
	(0.189)				(0.207)			
TFP (2008)		0.305				−2.349		
		(1.780)				(2.106)		
Wages (2008			0.105				−0.058	
			(0.170)				(0.216)	
Exports (2008)				−0.033				−0.018
				(0.034)				(0.037)
Constant	−2.411***	−2.687	−3.306**	−1.984***	−2.109**	0.652	−1.778	−2.140***
	(0.840)	(2.192)	(1.646)	(0.331)	(0.911)	(2.731)	(1.901)	(0.715)
Industry 2-digit ISIC	No	No	No	No	Yes	Yes	Yes	Yes
Observations	225	225	225	217	225	225	225	217
R-squared	0.000	0.000	0.002	0.006	0.149	0.154	0.149	0.167

The table presents the results of regressing changes in input tariffs between 2008 and 2012 at the 5-digit ISIC on industry characteristics in the initial year (2008). Employment (2008), TFP (2008), Wages (2008), and Exports (2008) are in log form and computed as the average employment, TFP, wages and exports of firms in the 5-digit industry. Input tariffs are constructed from the applied preferential tariffs that are used in the main model. Robust standard errors in parentheses *$p<0.10$; **$p<0.05$; ***$p<0.01$

Table 17 Constructed weighted tariffs and RER

2-digit ISIC Industry	Import weighted tariffs	Import weighted RER	Export weighted tariffs	Export weighted RER
15—Manufacture of food products and beverages	2.5	101.8	8.5	102.4
16—Manufacture of tobacco products	1.4	116.7	166.5	100.3
17—Manufacture of textiles	1.2	98.3	7.1	104.3
18—Manufacture of wearing apparel; dressing and dyeing of fur	3.6	100.6	15.8	104.8
19—Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	1.2	105.5	11.1	107.0
20—Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.1	96.5	5.0	97.1
21—Manufacture of paper and paper products	1.6	102.3	3.2	99.2
22—Publishing, printing and reproduction of recorded media	1.3	100.6	3.4	111.9
23—Manufacture of coke, refined petroleum products and nuclear fuel	1.7	96.3	2.5	97.8
24—Manufacture of chemicals and chemical products	1.5	101.6	6.7	101.7
25—Manufacture of rubber and plastics products	2.7	99.0	7.9	98.8
26—Manufacture of other non-metallic mineral products	1.1	99.4	6.4	100.4
27—Manufacture of basic metals	1.0	101.5	2.2	97.7
28—Manufacture of fabricated metal products, except machinery and equipment	2.0	96.7	4.0	96.8
29—Manufacture of machinery and equipment n.e.c	1.3	92.3	4.3	98.4
30—Manufacture of office, accounting and computing machinery	0.4	87.2	2.0	94.1
31—Manufacture of electrical machinery and apparatus n.e.c	1.8	93.6	9.0	95.4
32—Manufacture of radio, television and communication equipment and apparatus	0.6	94.2	4.9	99.8
33—Manufacture of medical, precision and optical instruments, watches and clocks	2.1	99.2	2.8	109.7
34—Manufacture of motor vehicles, trailers and semi-trailers	2.7	89.1	14.3	93.8
35—Manufacture of other transport equipment	1.6	93.2	11.4	101.0
36—Manufacture of furniture; manufacturing n.e.c	2.4	98.5	6.7	101.4

The data of weighted tariffs and RER are in 5-digit ISIC. The data above is aggregated into 2-digit ISIC and 5-years averaged. The exchange rates are in indexes with 2008 equal to 100

Table 18 Imported input variation by years. *Source*: Calculated from the Custom data

Year	Country—product variety (on average)		Product variety (on average)		Country variety (on average)	
	Mean	Max	Mean	Max	Mean	Max
2008	185.8	792	121.5	646	14.1	53
2009	166.2	690	108.6	456	13.0	47
2010	173.1	739	108.4	438	13.7	52
2011	199.7	857	119.9	490	14.7	58
2012	196.8	1204	119.3	544	14.5	49

Table 19 Sourcing decisions of a firm: an example. *Source*: Calculated from the Custom data

Firm X

ISIC 2-digit sector: 33

Imported intermediate product (HS 10 digit): 3919109000

Year	Countries of imports (top 4 countries[a] & the country offering the most expensive input[b])	Weight (kg)	Price per kg (USD)	Total countries of imports for the specific product
2008	Taiwan	443,443	6.92	16
	USA	61,920	12.14	
	Italy	22,467	4.56	
	Hong Kong	16,419	4.82	
	Mexico[b]	4	236.5	
2009	Taiwan	433,181	7.65	15
	USA	28,646	15.14	
	Japan	11,269	18.5	
	Italy	7571	4.2	
	South Africa[b]	38	149.71	
2010	Taiwan	397,993	7.78	15
	China	91,780	3.41	
	USA	40,995	15.32	
	Japan	22,938	16.96	
	Singapore[b]	82	41.96	
2011	Taiwan	439,263	7.71	14
	China	224,299	4.65	
	USA	41,924	16.6	
	Hong Kong	40,483	3.67	
	Singapore[b]	779	38.9	
2012	China	298,224	5.55	10
	Taiwan	220,807	8.54	
	USA	54,957	14.91	
	Japan	36,819	21.78	
	Malaysia[b]	2135	30.14	

[a]Top four sources of imported intermediate inputs in terms of volume (weight)

[b]Country of imports with the most expensive intermediate input

Table 20 Global Production Sharing (GPS) industries

Electronics	
3000	Office, accounting and computing machinery
3110	Electric motors, generators and transformers
3120	Electricity distribution and control apparatus
3130	Insulated wire and cable
3140	Accumulators, primary cells and batteries
3210	Electronic valves, tubes, etc
3313	Industrial process control equipment
Electrical appliances	
2930	Domestic appliances
3150	Lighting equipment and electric lamps
3190	Other electrical equipment
3220	TV/radio transmitters and line communication apparatus
3230	TV and radio receivers and associated goods
2925	Food/beverage/tobacco processing machinery
Automotive	
3410	Motor vehicles
3420	Automobile bodies, trailers and semi-trailers
3430	Parts/accessories for automobiles
3591	Motorcycles
3599	Other transport equipment
Other GPS	
2813	Steam generators
2899	Other fabricated metal products
2911	Engines and turbines (not for transport equip)
2912	Pumps, compressors, taps and valves
2913	Bearings, gears, gearing and driving elements
2914	Ovens, furnaces and furnace burners
2915	Lifting and handing equipment
2919	Other general purpose machinery
2921	Agricultural and forestry machinery
2922	Machine tools
2923	Machinery for metallurgy
2924	Machinery for mining and construction
2926	Machinery for textile, apparel and leather
2929	Other special purpose machinery
3311	Medical, surgical and orthopedic equipment
3312	Measuring/testing/navigating appliances
3320	Optical instruments and photographic equipment
3530	Aircraft and spacecraft parts

The classification is at the four-digit level of the International Standard Industrial Classification (ISIC), Athukorala and Kohpaiboon (6)

Table 21 Resource-based sectors

ISIC classification	
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
23	Manufacture of coke, refined petroleum products and nuclear fuel
2411	Manufacture of basic chemicals, except fertilizers and nitrogen compounds
2430	Manufacture of man-made fibres
2511	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
2519	Manufacture of other rubber products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
3610	Manufacture of furniture

Table 22 Definitions of certain regions used in the model

East Asia Region	Non-East Asia Region	Developed Countries	Developing Countries
ASEAN countries (except Indonesia)	Other than countries in East Asia Region group	EU (including the UK)	Other than countries in developed Countries group
Japan		USA	
South Korea		Canada	
China		Australia	
Taiwan		New Zealand	
Hong Kong		Japan	
North Korea			
Macau			

The classification of developed and developing countries uses the United Nation (UN) definition

Table 23 Manufacturing trades with East Asia Region and Non-EA Region, by GPS classif. (2012). *Source*: Calculated from the Custom data

Panel A	Average exports (000 USD)	Export share to East Asia (%)	Export share to Non-East Asia (%)
Non-GPS sectors	9424	35.9	64.1
GPS sectors	12,300	69.3	30.7
Panel B	Average imports (000 USD)	Import share from East Asia (%)	Import share from Non East Asia (%)
Non-GPS sectors	8847	46.2	53.8
GPS sectors	13,700	94.2	5.8
Panel C	Average import variations (number of items)	Average import variation from East Asia (number of items)	Average import variation from Non East Asia (number of items)
Non-GPS sectors	25.0	17.5	7.5
GPS sectors	53.0	45.2	7.8

Table 24 The first stage results using different definitions of tariffs

Variables	(1) Import variety	(2) Import variety	(3) Import variety	(4) Import value	(5) Import value	(6) Import value
Preferential tariffs—Top 10	−0.0223***			−0.0850***		
	(0.00572)			(0.0210)		
Preferential tariffs—East Asia		−0.0231***			−0.0818***	
		(0.00628)			(0.0226)	
MFN Tariffs			0.0104**			0.0397**
			(0.00508)			(0.0190)
Constant	1.804***	1.817***	1.821***	8.761***	8.830***	8.824***
	(0.190)	(0.190)	(0.188)	(0.624)	(0.622)	(0.620)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes
Crisis dummy	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,916	12,916	12,916	12,916	12,916	12,916
R-squared	0.045	0.045	0.043	0.044	0.043	0.042
Number of firms	3294	3294	3294	3294	3294	3294

Robust standard errors in parentheses $*p<0.10$; $**p<0.05$; $***p<0.01$

Table 25 Average imported inputs tariffs in Indonesia. *Source*: Calculated from TRAINS database

Year	Preferential tariffs—Top 10	Preferential tariffs—East Asia	MFN Tariffs
2008	2.93	2.81	3.99
2009	2.35	2.26	4.26
2010	2.18	1.89	5.02
2011	2.22	1.92	5.15
2012	0.32	0.32	4.96

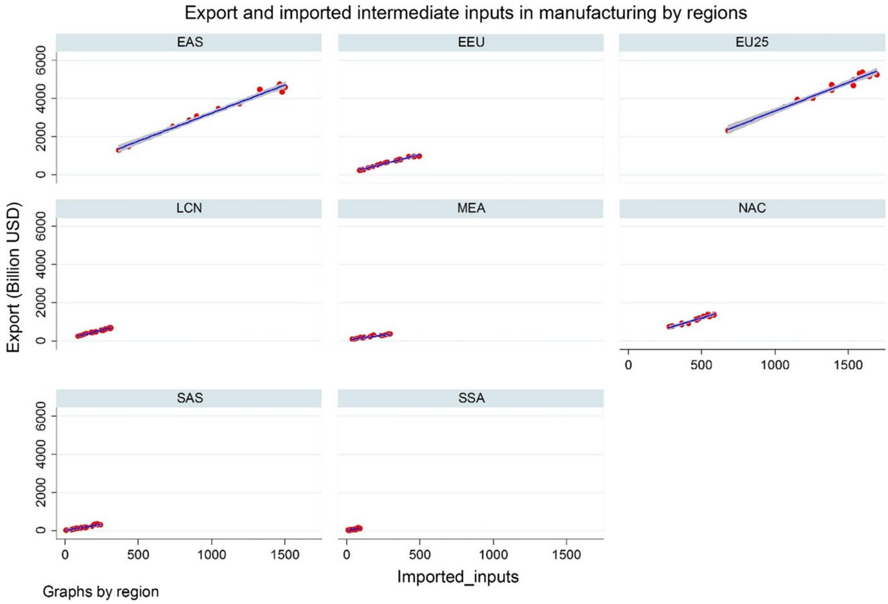

Fig. 1 Export and imported intermediate inputs in manufacturing sectors 2002–2015, by regions. *Source and notes*. The data are collected from UNCOMTRADE database. Both variables use standard region classification from the databases. Export data is constructed using ISIC Rev. 3: 2-digit sector 15–36. Imported inputs data is constructed using BEC classification: intermediate products for industry. EAS, East Asia and Pacific; EEU, Eastern Europe and Central Asia; EU25, European Union 25; LCN, Latin America and Caribbean; MEA, Middle East North Africa; NAC, North America; SAS, South Asia; SSA, Sub-Saharan Africa

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