Trade, Technology Transfer and Productivity Growth:

The Neglected Role of Imports

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Abstract

This study presents evidence that importing is a driver of international technology transfer. Using detailed firm level data from Indonesia, the paper shows that firms selling to sectors that rely more on imports have higher productivity than other firms. The findings also suggest that linkages through vertical supply relationships are the relevant mechanism through which import-driven technology transfer occurs. To our knowledge, these are the first firm-level results showing that imports play a role in technology transfer and the creation of technological capabilities. This is an important contribution towards establishing the existence of international knowledge spillovers, a critical component in the argument that trade promotes growth.

Keywords: Technology Transfer, Productivity, Imports, Indonesia, Supply Chain.
1. Introduction

Both international economics and international business literatures have had a lasting interest in the relationship between trade and technology transfer (Keller, 2001; Saggi, 2002; Werner, 2002). In both literatures, research has focused on two particular avenues for knowledge transfer: exports and foreign direct investment. Much less effort has been devoted to the relevant export counterpart, imports. This is precisely the focus of this paper. We show that imports are also a significant mechanism for acquiring knowledge from international markets and warrant greater attention from the research community.

In the economics literature, a number of studies using aggregate country-level data suggest trade to be an important driver of economic growth. These findings have prompted a number of more detailed studies looking in at the mechanisms that support these aggregate findings. Most existing work has focused on two mechanisms: exports by local firms and foreign direct investment (FDI). Despite some conflicting evidence, the majority of research associates both mechanisms with greater increases in productivity, although the direction of the causality is still under scrutiny. Likewise, the international business research has produced a number of significant results looking at international transfer of technology. Again, the locus of study has been either the multinational present in a foreign country, the establishment of alliances and networks, or the role of exports. No study has yet looked at the role of imports as a mechanism for technology transfer and local productivity enhancement, which is the objective of this paper.
The research asks whether imports can impact firm technological capabilities, as measured by productivity gains. Using a rich panel dataset of Indonesian manufacturers from 1988 to 1996, the paper examines factory productivity growth and its relation with imports. It finds strong evidence that firms selling to sectors that rely more on imports have higher levels of productivity than other firms. The findings also suggest that linkages though vertical supply relationships are the relevant mechanism through which import-driven technology transfer occurs. To our knowledge, these are the first firm-level results showing that imports play a role in technology transfer and the enhancement of technological capabilities. This is an important contribution towards establishing the existence of international knowledge spillovers, a critical component in the argument that trade promotes growth.

The paper is organized as follows. The next section discusses the theory and empirical literature on the relationship between trade, technology and productivity growth, discussing in particular the potential role of imports, the importance of the supply chain structure and Indonesia’s trade liberalization patterns. Section 3 discusses the data sources and measurement issues, Section 4 presents the results and Section 5 concludes.

2. Trade, Technology Transfer and Firm Productivity

2.1. Trade and Technology Transfer: What do we know?

Most north-south models of endogenous economic growth emphasize a product life cycle perspective of trade (see for example Grossman & Helpman, 1995). They posit that
innovative products are created in the North and, due to the lower relative Southern wages, these firms can successfully undercut Northern producers if they are able to acquire the relevant technology. This is the incentive for firms in catch-up economies to invest in acquisition of advanced technologies created elsewhere. But, motivation alone is insufficient. Southern firms also need a channel through which they can learn. In fact, international spillovers of knowledge are necessary conditions for technology migration from the more developed world into the developing countries (see Keller, 2001; Saggi, 2002 for recent reviews of these issues). However, empirical evidence of international knowledge flows and their impact on the technological capabilities in the less developed environment is weak.

The early and perhaps most well known literature exploring international knowledge spillovers uses country-level data to aim at correlating economic growth with increased openness to trade. Nevertheless, despite many papers addressing this issue, no consensus exists. For example, Sachs and Werner (1995) find empirical support for the view that open economies grow faster, while Rodriguez and Rodrik (1999) present a lengthy discussion of the problems with existing empirical work relating trade openness and growth and argue that the positive relationship between the two is far from being established. A more specific line of research has addressed directly the potential effect of international knowledge spillovers. Analyzing data for the OECD, Eaton and Kortum (1996) find that more than 50% of the growth in some countries derives from innovation in the United States, Germany, and Japan. Likewise, again using country-level data, Coe et al. (1995; 1997) suggest that international technology spillovers can be substantial and
that trade is plays an important role in these spillovers. (Connolly, 2001) specifically identifies imports in high technology sectors as a major source of productivity and economic growth. By contrast, Keller (1998) performs a similar analysis to Coe et al. (1995; 1997) but find no statistical support for the positive relation between trade and technology diffusion. More recent estimates that either used industry level data (Keller, 1997, 2000) or that separated general trade from capital goods trade (Xu & Wang, 1999) again showed imports to play a role in country productivity growth. The problem with these studies is that, by using country-level data, they are inherently limited in the number of observations and thus the results lack econometric robustness. In addition, it is difficult to isolate the channels that can contribute to technology transfer. Therefore, the results are very dependent on the particular definitions of the variables that the authors use in the analysis.

Because of these limitations, a greater emphasis has been placed on the use of firm-level data to evaluate the role of trade on growth and international knowledge spillovers. An early example is Irwin (1994), which looked at the semiconductor industry and found that learning spilled over as much internationally as it did in the same country. In this new research approach, two aspects have caught most of the attention of the researchers: exports and foreign direct investment (FDI). A number of authors have investigated whether entering a foreign market through exports may work as a mechanism through which firms learn (Blalock & Gertler, 2002; Clerides et al., 1998; Roberts & Tybout, 1997). So far, there have been mixed results, with the positive effect depending on the characteristics of the market and the initial conditions of the firms that decide to export to
a foreign market. Likewise, a growing body of research on the role of FDI as a
determinant for technology transfers and productivity growth has produced conflicting
evidence (see Blomstrom & Kokko, 1998; Keller, 2001; Kumar, 1996 for extensive
reviews).

Recent work by Blalock and Gertler (2002) examines this contradicting evidence. The
authors’ empirics clearly distinguish the notion of horizontal spillovers, those that happen
towards firms in the same business than the potential originator of the technology, from
vertical spillovers, that may happen towards clients and/or suppliers of the relevant
technology owner. They explain how most of the conflicting results have focused on the
former notion of horizontal spillovers and explain why one may expect to find such
diverse results when trying to assess FDI spillovers. On the contrary, the authors claim
that the much less explored context of vertical spillovers is much more critical and go on
to present empirical evidence to demonstrate such effect.

But while mounting research looking at firm-level spillover effects of FDI and exports
exists, another important element seems to be have been left out the discussions on trade
as a mechanism for technology transfer: the role of imports. In fact, to our knowledge,
there has been no firm level evidence analyzing the potential impact of imports on
productivity or local technological capabilities.

A similar pattern can be found when looking at the literature in international
management. A recent review of research trends based on articles published in 20 top
journals by Werner (2002), distinguishes between foreign direct investment related research and international exchange oriented work (as well as a more recent interest in hybrid organizations such as networks and international joint ventures). Within the second area, substantial work exists concerning exports, including its determinants, intermediaries and consequences, but situation is quite different concerning imports. In the 1996-2000 time frame considered in the review paper, only one article (Liang & Parkhe, 1997) addressing the role of imports is listed, and also with a review character. One of the recommendations of the Werner paper is precisely the need to have more research on what concerns import exchange mechanisms, a note that echoes the conclusions of the earlier paper by Liang (1997).

The literature is even scarcer when addressing knowledge and technology transfer. Recent research has been overwhelmingly geared towards transfer within the multinational enterprise (see for example Madhok & Osegowitsch, 2000; Ostry, 1998) and through foreign direct investment to local firms (Liu et al., 2000). Research that looks at knowledge transfer in the context of exchange mechanisms is much more limited. A notable exception is Hult et al. (2000), but their interest is on how the local purchasing organization learns about selecting foreign suppliers, rather than on the firm ability to acquire relevant technology.
2.2. The argument: Imports, Technology Transfer and Supply Chains

According to existing models (see Connolly, 2001; Keller, 2001; Rivera-Batiz & Romer, 1991), the two basic mechanisms through which international technology transfer takes place are direct learning about foreign technology, or incorporation of new intermediate products invented abroad in the local production chain. In the first situation, an original design invented in a particular region is learned elsewhere (for example by reading a patent, reverse engineering a product, or licensing a technology). Since productivity is assumed to depend on the local stock of knowledge, learning the new design will increase the local knowledge pool and, as a result, generate a positive impact on local productivity. A second potential mechanism entails the idea that using the foreign intermediate product includes the usage of the embodied technological capability and R&D of the foreign producer. If this intermediate good cost less than its opportunity cost, there may be a productivity gain for the local producers. The key hypothesis explored in the paper is that the first mechanism, and not the second, is at the core of the local improvement process. Moreover, as explained below, this productivity enhancement happens along the domestic supply chain, i.e. to local suppliers of products equivalent to the imports, instead of to the importers themselves.

To understand how the technology transfer process might work, it is important to recognize that the purchase of foreign intermediate goods is by no means a guarantee that there will be local learning. There are at least three obstacles to such learning. First, the relevant knowledge necessary to produce the new product (or process) is only partially
embedded in the product itself, even if substantial reverse engineering is used (Bresman et al., 1999; Madhok & Osegowitsch, 2000). Simply working with or looking at the product, blueprints, patents or other forms of codified knowledge does not necessarily uncover the knowledge needed to appropriate the technology (Cohen et al., 2000). Much of the required know-how is tacit and can only be conveyed through experience or apprenticeship. Second, the foreign owner of the relevant knowledge may not interested in transferring it elsewhere, in particular if the local companies are seen as potential lower cost competitors. In fact, the owner may actively discourage transfer by minimizing the availability of relevant know-how. For example, the proprietor might withhold some product specifications, decline to sell the latest-generation products, or embed proprietary knowledge into process innovation rather than more visible product innovation. Third, even if the possibility to transfer technology from abroad exists, the local firm importing the intermediate product is unlikely to be interested in acquiring the technology necessary to produce it. For example, a car assembler is interested in having high quality and low cost parts, and not in learning how to manufacture them.

Reconciling the potential for learning from imports with the difficulties highlighted above requires further analysis of the incentives and the nature of buyer-supplier or supply chain relations. One of the key issues is to recognize that, while importing firms might not be interested in acquiring the technology supporting the products they bring form abroad, local suppliers of equivalent intermediate products have the right set of incentives to capture technologies that enable them to better compete with and/or displace foreign suppliers. While firms that do not compete with foreign suppliers may be
insulated from knowing about technologies developed elsewhere, those disputing the market with international producers are more likely to be exposed to best practices. They are also under more intense competition from these foreign firms. As a result, they are more likely to see their profitability, market share and even survival threatened if they don’t adopt new technologies and best practices. On the other hand, it is easy to understand, that ceterus-parius on ability, a domestic client would prefer a local supplier because of reduced transportation costs and more reliability on delivery. Therefore, local clients have an incentive to help local suppliers in finding and transferring relevant technologies to try to displace foreign suppliers, even if that is not in the best interest of their existing suppliers.

The question though, might be why wouldn’t a profit-maximizing firm adopt the most efficient means of production available, even in the absence of international competition in its domestic market? On the one hand, one could easily reason that in a context confined to local competition, there may be a lack of knowledge about the latest technologies and business methods. Likewise, in the absence of outside pressure, the benefits of adopting a new technology may not justify the personal cost of the effort incurred by non-owner managers—a form of x-inefficiency. On the other hand, in a context of local competition, the additional local market returns (losses) from (the absence of) investing in a new technology may be very small. But this situation could dramatically change if a foreign supplier enters the local market and starts taking share away form local suppliers based on superior technologies.
The discussion above suggests that local suppliers, when exposed to foreign competition in their markets, face a set of incentives that would conduce to an active search to learn from imports. Nevertheless, it is also crucial to appreciate if the appropriate mechanisms for learning and technology transfer exist. Fortunately, a number of recent studies looking at vertical or buyer-supplier relations (Womak, Jones and Roos, 1990; Takeishi, 2001; Clark and Fujimoto, 1991; Lamming 1993; Dyer and Ouchi, 1993; Liker et al, 1996; Nishiguchi, 1993) have clearly demonstrated that an active exchange of knowledge in product development and manufacturing between clients and suppliers exists, and that benefits from such exchanges accrue for both parties. These studies suggest that local clients provide local suppliers with the necessary link to relevant technological information and knowledge, especially if such clients are importing from world-class foreign suppliers. This link can be as little as providing contacts for relevant technologies, or as much as finding the right partner and sharing the cost of transferring technology.

The set of incentives and learning mechanisms described above supports the base hypothesis that ‘learning from downstream imports will happen at upstream local suppliers of products that compete with imports in the same market space’.

Although each of the specific mechanisms for technology transfer described above is typically unobservable in the data, one can identify the results of such technology transfer by looking at productivity gains. Moreover, if supply chains are the relevant conduit for technology transfer associated with imports, then one would expect, ceteris paribus, that
local firms supplying to industries and regions with greater levels of inputs purchased in foreign markets would show greater productivity growth than other local firms. Conversely, one will hypothesize that learning and technology transfer to the firms that buy the foreign intermediate goods will be of less importance than supply chain learning.

2.3. Indonesian Manufacturing and Trade Policy

Indonesia’s manufacturing sector is an attractive setting for research on technology transfer from importing for several reasons. First, with the fourth largest population in the world and thousands of islands stretching over three time zones, the country has abundant labor and natural resources to support a large sample of manufacturing facilities in a wide variety of industries. Second, Indonesian government agencies employ a number of well trained statisticians who have collected exceptionally rich manufacturing data for a developing country. Further, the country’s size and resources support a full supply chain, from raw materials to intermediate and final goods. Third, rapid and localized industrialization provides variance in manufacturing activity in both time and geography. Fourth, the country’s widespread island archipelago geography and generally poor transportation infrastructure create a number of local markets, each of which can support independent supply chains. Last, the Indonesian government legislated a major reform of the trade regime in the mid and late 1980’s, shifting from a policy of import substitution to one of export promotion. In 1986, Indonesia substantially reduced import tariffs, reformed customs administration, and introduced a generous duty drawback scheme, thus prompting an overall growth in the import market. The overall share of imported
materials in Indonesian manufacturing has grown from 28 to 35 percent, an increase likely driven by the liberalization of the trade regime.

3. Data, Sample Selection, and Measurement

3.1. Sources

The analysis is based on data from the Republic of Indonesia’s Budan Pusat Statistik (BPS), the Central Bureau of Statistics. The primary data are taken from an annual survey of manufacturing establishments with more than 20 employees conducted by Biro Statistik Industri, the Industrial Statistics Division of BPS. Additional data include several input and output price deflators. The remainder of this section describes each dataset and the measurement of firm learning from imports.

The principal dataset is the Survei Tahunan Perusahaan Industri Pengolahan (SI), the Annual Manufacturing Survey conducted by the Industrial Statistics Division of BPS. The SI dataset is designed to be a complete annual enumeration of all manufacturing establishments with 20 or more employees from 1975 onward. Depending on the year, the SI includes up to 160 variables covering industrial classification (89 input-output table codes), ownership (public, private, foreign), exports, status of incorporation, assets, asset changes, electricity, fuels, income, output, expenses, investment, labor (head count, education, wages), raw material use, national and imported, machinery, and other

1 We identify names in Bahasa Indonesia, the language of most government publications, with italics. Subsequently, we use the English equivalent or the acronym.
specialized questions. BPS submits a questionnaire annually to all registered manufacturing establishments, and field agents attempt to visit each non-respondent to either encourage compliance or confirm that the establishment has ceased operation.\(^2\) Because field office budgets are partly determined by the number of reporting establishments, agents have some incentive to identify and register new plants. In recent years, over 20,000 factories have been surveyed annually. Government laws guarantee that the collected information will only be used for statistical purposes. However, several BPS officials commented that some establishments intentionally misreport financial information out of concern that tax authorities or competitors may gain access to the data. Because the fixed-effect analysis used here admits only within-factory variation on a logarithmic scale, errors of under- or over-reporting will not bias the results provided that each factory consistently misreports over time. Further, even if the degree of misreporting for a factory varies over time, the results are unbiased provided the misreporting is not correlated with other factory attributes in the right-hand-side of the regression.

Not surprisingly, particularly in a developing country environment, there is a high level of non-reporting and obvious erroneous responses to many of the survey questions. Questions that require some accounting expertise, such as the replacement and book value of fixed assets, were especially problematic. We have cleaned key variables to

\(^2\) Some firms may have more than one factory, we refer to each observation as an establishment, plant, or factory. BPS also submits a different questionnaire to the head office of every firm with more than one factory. Although these data were not available for this study, early analysis by BPS suggests that less than 5 percent of factories belong to multi-factory firms. We therefore generalize the results to firms.
minimize noise due to non-reporting, misreporting, and obvious mistakes in data keypunching. The analysis here starts from 1988, the first year data on firm capital are available. To avoid measurement error in price and other uncertainties introduced by the 1997-1998 Asian financial crisis, the last year of analysis is 1996. We deflated output, materials, and capital to express values in real terms. The deflators are based on *Indeks Harga Perdagangan Besar* (IHPB), wholesale price indexes (WPI), published by BPS.

### 3.2. Measurement

The analysis estimates a production function to reveal the effect of changes in within-industry on establishment productivity over time. A positive contribution from imports suggests that firms are learning through this mechanism. As noted above, two types of potential learning mechanisms are considered – own imports and downstream. Learning through own imports is measured directly by evaluating the incorporation of imports in purchased inputs. The measure is varied by industry, time and region. The region definitions are the 14 Indonesian provinces on most industrialized islands of Sumatra and Java (and neighboring Bali). We have excluded the provinces located in Indonesia’s outer islands and the former Portuguese colony of East Timor because what little industrial activity that occurs is largely based on natural resource extraction and processing rather than the production of new goods. The regional approach appeals to Indonesia’s vast island geography and poor inter-region transportation infrastructure in assuming local markets, i.e., firms in the same region are more likely to consume that intermediate goods
output. We determine imports by industry and region, to avoid the endogeneity of a particular factory’s decision to buy from foreign suppliers.

\[
Own\_Sector\_Imports_{jrt} = \frac{\sum_{i \in jrt} Foreign\_Purchases_{it}}{\sum_{i \in jrt} Purchases_{it}} \quad (1)
\]

\[
Province\_Downstream\_Imports_{jrt} = \sum_k \alpha_{jkt} Own\_Sector\_Imports_{jrt} \quad (2)
\]

Equations 1 and 2 express the calculation for sector \( j \), region \( r \), at time \( t \), where \( i \in jrt \) indicates a factory in a given sector, region, and time. \( Purchases_{it} \) is the amount of materials purchased for factory \( i \) at time \( t \) and \( Foreign\_Purchases_{it} \) are the corresponding values for purchases made from foreign suppliers. \( Own\_Sector\_Imports_{jrt} \) is the measure of penetration of imports for a given sector \( j \), region \( r \), and time \( t \), where region is one of the 27 individual regions.

Potential for active supply chain learning is measured using the \( province\_Downstream\_Imports_{jrt} \) variable. This variable is calculated by summing the output shares purchased by client manufacturing sectors multiplied by the share of own sector imports in those sectors. For example, suppose that half of the wheat flour sector output is purchased by the bakery industry and the other half is purchased by the pasta industry. Further, suppose that the bakery industry has no foreign purchases but that pasta sector buys half of the inputs from abroad. The calculation of downstream import penetration for the flour sector would yield 0.25 = 0.5(0.0)+0.5(0.5). So, \( \alpha_{jkt} \) is the
proportion of sector j output consumed by sector k at time t. The coefficient \( \alpha_{jkt} \) is calculated from national Input Output (IO) Tables. Values before and including 1990 follow from the 1990 IO table, values of \( \alpha_{jkt} \) from 1991 through 1994 are linear interpolations of the 1990 and 1995 IO tables, and values of \( \alpha_{jkt} \) from 1995 on are from the 1995 IO table. Recall that \( \alpha_{jkt} \) does not have a region \( r \) subscript because the IO table is generated for the entire national economy.

We obtain establishment-level productivity by estimating a translog production function: \(^3\)

\[
\ln Y_{it} = \beta_0 I_{pts_{jrt}} + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln M_{it} + \beta_4 \ln^2 K_{it} + \beta_5 \ln^2 L_{it} + \beta_6 \ln^2 M_{it} + \\
\beta_7 \ln K_{it} \ln L_{it} + \beta_8 \ln K_{it} \ln M_{it} + \beta_9 \ln L_{it} \ln M_{it} + \alpha_i + \gamma_t + \epsilon_{it}
\]

where \( Y_{it} \), \( K_{it} \), \( L_{it} \), and \( M_{it} \) are the amounts of production output, capital, labor, and materials for establishment \( i \) at time \( t \), \( \alpha_i \) is a fixed effect for factory, and \( \gamma_t \) is a dummy variable for year \( t \). \(^4\) A positive coefficient on \( I_{pts_{jrt}} \) indicates that imports are associated with higher productivity. Output, capital, and materials are nominal rupiah values deflated to 1983 rupiah. Labor is the total number of production and non-production workers.

\(^3\) A joint F-test on the quadratic terms in the translog production function reject the hypothesis that the terms are jointly equal to zero. Hence, we reject a simpler Cobb-Douglas production function in favor of the more flexible translog functional form. The translog also allows us to allow non-unitary elasticity of substitution between inputs and thereby better condition on economies of scale.

\(^4\) A Hausmann test reject the use of random effect estimation.
3.3. Sample Selection

We used several criteria to select the sample for the estimation of Equation 1 as to ensure maximum robustness in our results. First, because foreign owned firms are more likely to import than wholly Indonesian owned firms, it would be easy to confound changes in importing behaviour with changes in foreign ownership. To avoid any confounding, a particular concern since the liberalization of the Indonesia’s trade regime was accompanied by reforms of foreign investment regulations as well, the sample is limited to wholly Indonesian owned firms over the entire panel period. Another potential problem is whether the downstream import variable is not just a proxy for downstream foreign direct investment (FDI), a factor known to influence own and upstream firm productivity (Blalock and Gertler, 2003; Blomstrom, M. & Kokko, A. 1998). This will happen if downstream FDI is highly correlated with downstream imports, making the two variables virtually indistinguishable. As a result, it will be crucial to control for FDI, making sure that any imports result is robust to the introduction of this variable.

Table 1: Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIMP: Own Imports</td>
<td>6126</td>
<td>0.1725</td>
<td>0.2774</td>
<td>0</td>
<td>0.2774</td>
</tr>
<tr>
<td>PVFDI: Province Downstream FDI</td>
<td>6169</td>
<td>0.0503</td>
<td>0.1063</td>
<td>0</td>
<td>0.9869</td>
</tr>
<tr>
<td>PDIMP: Province Downstream Imports</td>
<td>6169</td>
<td>0.0689</td>
<td>0.10988</td>
<td>0</td>
<td>0.9027</td>
</tr>
</tbody>
</table>
Table 1 shows descriptive statistics for the dependent variables for all the factories in the cleaned dataset. The important fact revealed in Table 1 is that downstream imports are a rather small number, on average less than 7%. This observation suggests that the import learning effect addressed in the paper is associated with a sector’s (or at least a significant amount of firms in it) decision to begin importing, rather than a widespread exposure to imported goods. Table 2 shows the correlations between the same variables. As it can be seen in Table 2, the correlation between the critical variables are not dramatic, suggesting that they are not proxies of each other.

Another set of issues to be considered is how might the base hypothesis be adjusted by the nature of the firm. First, an immediate corollary from the hypothesis of the upstream learning is the idea that firms in intermediate goods ought to learn more through this mechanism when compared to final goods sector firms. With a few notable exceptions, final goods companies have little access to clients that could act as the international learning link hypothesized above. Therefore, one would expect less downstream learning opportunities. Intermediate goods are defined as the 37 sectors that sold 50 percent or more of their output to other manufacturing sectors as indicated in either the 1990 or 1995 IO table (results are robust to alternative definitions).
Table 2: Dowstream Imports and Own Sector Imports in 1988 and 1996 in percent values

<table>
<thead>
<tr>
<th>Variable</th>
<th>PDIMP</th>
<th>PVFDI</th>
<th>OIMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDIMP</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PVFDI</td>
<td>0.6107</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>OIMP</td>
<td>0.4342</td>
<td>0.2519</td>
<td>1</td>
</tr>
</tbody>
</table>

Second, the ability of companies to absorb new technologies through supply chains is also dependent on their absorptive capacity. While most authors use the level of R&D as a proxy for this concept (based on Cohen and Levinthal, 1990), the context of developing countries is one of very low firm investment in research and development activities. Therefore, the firm level of human capital, measured through the proportion of employees with complete high school, will be used as a proxy to measure absorptive capacity. A third aspect that may help qualify the results is to look at how firm size affects the results. In principle, larger firms have more resources to access and leverage foreign technology. Therefore, one ought to expect to find stronger downstream learning opportunities for larger companies. Finally, the results test for how government ownership might affect performance, trying to inquire whether public ownership might affect the learning mechanism identified before.
4. Results

The results provide strong evidence that Indonesian supplier productivity benefits from imports. Table 3 presents the results of estimating the production function shown in Equation 3. Column (1) displays results with only the effect of downstream imports, where it is shown as significant below 1%. Because the production function is in log-linear form, the coefficients represent elasticities. Therefore, the 0.12 coefficient on \textit{Downstream Imports} suggests that factory output increases approximately 12 percent as the proportion of downstream of downstream materials imported rises from 0 to 1.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|}
\hline
 & (1) & (2) & (3) & (4) \\
\hline
Dependent Variable: Output & & & & \\
\hline
Downstream Imports & 0.117 (0.000) & 0.064 (0.024) & 0.114 (0.000) & 0.062 (0.030) \\
\hline
Vertical FDI & & 0.084 (0.001) & & 0.084 (0.001) \\
\hline
Own Imports & & & 0.0005 (0.956) & 0.002 (0.883) \\
\hline
\#. Factories & 23,090 & 23,090 & 23,083 & 23,083 \\
R-squared & 0.94 & 0.94 & 0.94 & 0.94 \\
\hline
\end{tabular}
\caption{Productivity Base}
\end{table}

Note: \textit{p} values in parentheses.

All translog variables identified in equation 3 as well as year dummies included but not reported.

Columns (2) to (4) represent the sets of controls discussed in section 3.3. As it can be observed, the effect of \textit{Downstream Imports} is robust to the introduction of any or all of
the relevant control variables. As established by Garrick and Blalock (2002), downstream or vertical FDI, included in columns (2) and (4), is positive and significant. Moreover, the inclusion of VFDI in the equation lowers the coefficient of *Downstream_Imports* to roughly 0.06, but the significance level is always below 5%. Columns (3) and (4) also confirm the hypothesis that own imports not only do not affect the main results, but are also non-significant.

**Table 4: Characterizing Learning Pattern**

<table>
<thead>
<tr>
<th>Dependent Variable: Output</th>
<th>Base Result</th>
<th>Firms with more than 50 workers</th>
<th>Only Intermediate Goods</th>
<th>Only Final Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Downstream Imports</strong></td>
<td>0.064 (0.024)</td>
<td>0.110 (0.004)</td>
<td>0.089 (0.003)</td>
<td>0.037 (0.238)</td>
</tr>
<tr>
<td><strong>Vertical FDI</strong></td>
<td>0.084 (0.001)</td>
<td>0.091 (0.005)</td>
<td>0.063 (0.016)</td>
<td>0.062 (0.022)</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>106,302</td>
<td>57,676</td>
<td>40,642</td>
<td>74,795</td>
</tr>
<tr>
<td><strong># Factories</strong></td>
<td>23,090</td>
<td>10,759</td>
<td>8,493</td>
<td>16,343</td>
</tr>
<tr>
<td><strong>R-squared</strong></td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
</tr>
</tbody>
</table>

To test for the robustness of the previous results and the associated hypothesis discussed in section 3.3, Table 4 presents the results with the appropriate subsets of the complete sample. As predicted, larger firms are better able to leverage this international learning. Likewise, the results are stronger for the sub-sample of intermediate goods. On the contrary, the coefficient is smaller and the significance level drops when considering the final goods sectors. As readily understood, all results are robust to the introduction of VFDI. These results confirm the hypothesis described in section 3.3.
Table 5 describes how government ownership and human capital affect the ability of firms to leverage on the international technology learning. The results suggest that government ownership hampers the ability of the firm to reap the benefits from exposure to international knowledge. Several reasons can justify this result. For example, one could argue that government owned firms might feel that they are better protected from international competition, even if present in their markets. This may limit their incentives to learn about foreign technologies. As anticipated, human capital is an important driver of productivity enhancement. Although significant at 10%, it can be observed that its inclusion in the regression makes the downstream import coefficient drop to a low magnitude and lose its significance, only for the magnitude of the coefficient to be transferred and reinforced around the interaction term.

Table 5: Learning Patterns

<table>
<thead>
<tr>
<th>Dependent Variable: Output</th>
<th>Base Result</th>
<th>Government Ownership</th>
<th>Human Capital (High School)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Imports</td>
<td>0.117 (0.000)</td>
<td>0.131 (0.000)</td>
<td>0.041 (0.261)</td>
</tr>
<tr>
<td>PDIMP X Government Owned</td>
<td>-0.199 (0.030)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDIMP X Human Capital</td>
<td></td>
<td></td>
<td>0.1498 (0.103)</td>
</tr>
<tr>
<td>Observations</td>
<td>106,302</td>
<td>106,302</td>
<td>87,367</td>
</tr>
<tr>
<td>#. Factories</td>
<td>23,090</td>
<td>23,090</td>
<td>17,028</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
</tr>
</tbody>
</table>
5. Summary and Implications

This study presents evidence that importing is a driver of international technology transfer. Using detailed firm level data from Indonesia, the paper shows strong and significant evidence of learning from downstream imports. Specifically, it shows that firms selling to sectors that rely more on imports have higher productivity than the rest. These results are robust to a number of different specifications and control variables.

The findings also suggest that linkages though vertical supply relationships are the relevant mechanism through which import-driven technology transfer occurs. Ceterus-paribus, a local client would prefer a capable local supplier to a distant one in most cases because of lower transportation costs and more reliable delivery. Local clients thus have an incentive to help local suppliers obtain relevant technologies so that the local vendors may eventually displace foreign suppliers.

The characterization of the learning process reveals that larger firms and those in intermediate goods sectors are better able to leverage this international learning. Consistent with previous work, results also suggest that human capital – thought as representing the firm’s absorptive capacity – plays an important role in facilitation of this learning process.
To our knowledge, these are the first firm-level results showing that imports play a role in technology transfer and the creation of technological capabilities. This is an important contribution towards establishing the existence of international knowledge spillovers, a critical component in the argument that trade promotes growth.

6. References


Kumar, N. 1996. Foreign Direct Investments and Technology Transfers in Development: A Perspective on Recent Literature: The United Nations University.


