Imported Intermediates, Absorptive Capacity and Productivity: Evidence from Ghanaian Manufacturing Firms

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Abstract:

This paper analyses whether the use of imported intermediates improves productivity using firm-level panel data of manufacturing firms in Ghana covering the period between 1991 and 2002. This includes examining the importance of absorptive capacity in enhancing the productivity gains from imported intermediates. We propose lagged relative productivity as a new measure of absorptive capacity (ABC). For any given period, ABC is defined as the natural logarithm of a firm's total factor productivity in the previous period relative to the firm's initial total factor productivity. An alternative measure of ABC considers real value added per worker in lieu of total factor productivity. Overall, we find that firms with high levels of absorptive capacity derive productivity gains from the contemporaneous and prior use of imported intermediates, particularly for firms operating in the input-intensive industries. Our findings are robust to different specifications of the base model and different estimation techniques.

JEL classification: F14; D22; D24; O33

Keywords: Trade, Absorptive capacity, Productivity, Manufacturing, Imported intermediates, Ghana.

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1. Introduction

Over the past three decades, the link between trade and growth has been a central research topic in international trade. In recent years, a growing number of studies show that an increasing share of international trade consists of intermediate inputs. Firms potentially gain substantial benefits through access to imported intermediates, particularly higher quality inputs (Goldberg, Khandelwal, Pavcnik, & Topalova, 2010; Imbruno, 2015; Kugler & Verhoogen, 2009; Miroudot, Lanz, & Ragoussis, 2009). While evidence on the growing share of trade in intermediates is well-documented, its role in improving international technology transfers and productivity across countries is not well researched, particularly in the context of sub-Saharan Africa (SSA).

Trade in intermediates is one of the main channels for technology diffusion and a potential source of enhancing firm productivity. High-tech inputs are an important source of research and development (R&D) spillovers, particularly for firms operating in developing economies (Acharya & Keller, 2009; Madsen, 2007; Xu & Wang, 1999). In most cases, firms operating in developing economies depend heavily on imported technology from advanced economies rather than investing in indigenous R&D (Acharya & Keller, 2009; Eaton & Kortum, 2001; Kasahara & Rodrigue, 2008). The use of imported technology potentially provides an enabling environment for firms in developing countries to assimilate R&D spillovers. Developing economies enhance growth by using imported intermediates from countries that carry out substantial R&D activities (Bell, 2007; Coe, Helpman, & Hoffmaister, 1997). Therefore, trade in intermediate inputs has the potential to help firms in developing economies to narrow the productivity gap with firms in advanced economies.

In view of the growing fragmentation of production, the question whether firms enhance productivity from the use of imported intermediates or not is crucial in understanding the pattern of international trade and its impact on productivity. The primary objective of this paper is to analyse whether the productivity impact of imported intermediates depends on the

absorptive capacities of firms using firm-level panel manufacturing data from Ghana over the period of 1991-2002. At the firm level, absorptive capacity captures the ability to identify, absorb and assimilate new external knowledge and advanced technologies over time.

The emerging evidence for the link between imported intermediates and productivity is inconclusive. Some researchers report that imported intermediates have a negative impact on productivity or are associated with negligible productivity gains (Biesebroeck, 2003; Muendler, 2004). Contrary evidence suggests that imported intermediates improve productivity (Goldberg et al., 2010; Kasahara & Rodrigue, 2008; Yasar, 2013). Further, Amiti and Konings (2007) establish that a reduction in input tariffs leads to productivity gains, particularly for importing firms in Indonesia, while Halpern, Koren, and Szeidl (2011) find that firms that exclusively use foreign input varieties in the production processes boost productivity by twelve percent in Hungary. Defever, Imbruno, and Kneller (2012) show that official non-importing Chinese firms benefit from input trade liberalization by indirectly accessing foreign inputs from trade intermediaries. The mixed findings from the literature can be due to the omitted variable bias, with variables capturing absorptive capacity not having been included in most studies (Kasahara & Rodrigue, 2008; Muendler, 2004).²

Most studies that control for absorptive capacity (ABC) tend to use measures, such as the proportion of skilled workers (Augier, Cadot, & Dovis, 2013; Yasar, 2013), or the relative total factor productivity (TFP) difference between a firm and an industry leader (Girma, 2005; Kim, 2015). For instance, using a cross-section of firms from African countries, Foster-

² Further evidence is provided in a number of country-level studies. These studies examine whether high productivity firms self-select into import markets and/or investigate the learning-by-importing hypothesis. In general, these studies show that sourcing of inputs from abroad is associated with productivity improvement. Countries studied are Belgium (Muûls & Pisu, 2009), Germany (Vogel & Wagner, 2010), Italy (Castellani, Serti, & Tomasi, 2010; Conti, Lo Turco, & Maggioni, 2013), Spain (Fariñas & Martín-Marcos, 2010), Sweden (Andersson, Lööf, & Johansson, 2008), Colombia (Kugler & Verhoogen, 2009), Indonesia (Blalock & Veloso, 2007) and India (Acharya & Keller, 2009; Goldberg et al., 2010; Topalova & Khandelwal, 2011).

McGregor, Isaksson, and Kaulich (2013) show that firms with a high share of white-collar workers out of total full-time employees enjoy higher productivity gains from importing. These commonly used measures of ABC fail to capture dynamic elements of the relative improvement or deterioration in a firm's ability to assimilate external technologies.

There is now a substantial literature that treats firms as learning organizations, building on the seminal work of Penrose (1995) in which management capacity expands over time with the experience (learning) of the extant group of managers. In related work, Cohen and Levinthal (1990) treat the ability of a firm to absorb external technology as a result of the firm's own experience in research and development (R&D). Importantly, the absorptive capacity of the firm develops alongside direct investments in building absorptive capacity.

We utilise a measure of absorptive capacity that aims to capture its dynamic character. We take a firm's past productivity improvement or deterioration relative to the initial level of productivity to indicate its absorptive capacity and measure this dynamic capability by the ratio of lagged productivity to initial productivity (measured at the start of the sample period). We expect dynamic capability to be particularly important in the context of a developing economy, where most firms typically operate well inside the technology frontier as determined by leading firms in the developed economies.

This study uses firm-level data from Ghanaian manufacturing firms. Ghana is an interesting case study given its status as one of Africa's most devout reformers. Ghana embarked on an IMF-supported Economic Recovery Programme (ERP) in 1983, transforming from a tightly controlled trade regime to an open economy since 1986. The adoption of a new licensing system in 1986 allowed the purchase of non-consumer goods from abroad without restrictions (Ackah, Adjasi, & Turkson, 2014; Barwa, 1995; Rodrik, 1999).

In addition, Ghana introduced a number of policies in the 1990s aimed at facilitating the purchase of foreign intermediate goods deemed essential for rapid industrialisation and economic growth. These include, but are not limited to, exemptions from duty on capital goods, raw materials imported for the manufacture of pharmaceuticals and other chemical products, and temporary importation of goods that are re-exported within three months of entry (Aryeetey & Fosu, 2002). In general, empirical evidence suggests that trade liberalisation has had a positive impact on productivity in Ghana. Firms exposed to import competition have higher productivity as measured by TFP compared to protected firms (see Ackah, Aryeetey, & Morrissey, 2012).

Investment in R&D activities in Ghanaian manufacturing sector is abysmally low (Akay & Yuksel, 2009; Lall, Navaretti, Teitel, & Wignaraja, 1994). As a result, firms tend to depend more on assimilation of international technology spillovers. In contrast, firms in advanced economies tend to devote significant amounts of resources to R&D activities. Nearly all R&D spending is concentrated in advanced economies (Coe et al., 1997; Kasahara & Rodrigue, 2008). In contrast, there is no evidence that importing firms in Ghana devote significant resources to R&D activities. Imported technology as opposed to R&D spending is potentially the key source of stimulating productivity growth in Ghanaian manufacturing sector.

Manufacturing firms in Ghana rely heavily on higher-quality inputs produced in advanced economies. Firms in advanced economies tend to enjoy a number of competitive advantages, such as access to greater varieties of higher-quality inputs, low costs, economies of scale resulting from mass production for the global market, a well-developed industrial base, among others. This suggests that the impact of imported inputs on productivity for manufacturing firms in Ghana is potentially more pronounced compared to their counterparts in advanced economies. McCann (2009) shows that exporting leads to productivity improvement in Ireland, while importing has negligible impact in comparison. The fact that

Ireland serves as a host to a multitude of high quality input-providing firms may explain why the use of imported inputs does not necessarily lead to productivity gains. Most of the imported inputs in Ireland may not be of higher quality compared to domestic inputs. This is likely in sharp contrast with manufacturing firms in Ghana that depend on higher quality inputs produced in advanced economies, such as Ireland.

Our contributions to the literature are threefold. First, we develop a simple model incorporating the interplay between imported intermediates, absorptive capacity, and productivity. In this respect, lagged relative productivity (LRP) is proposed as a new measure of ABC. This measure is found to be more robust than the commonly used measures in the literature. The findings suggest that the productivity effect of imported intermediates varies with the level of absorptive capacity of firms. Firms with high levels of absorptive capacity, measured by lagged relative productivity, increase their productivity from the use of imported intermediates in either the current or prior period.

Second, we show that the joint productivity effect of imported intermediates and absorptive capacity is industry dependent. Firms operating in industries, such as chemical, machinery and metal products, that utilise a larger share of imported intermediates augmented by high levels of ABC enjoy large productivity gains. Conversely, there is no strong evidence that firms operating in industries, such as textiles and bakery that use a smaller share of imported intermediates in addition to having a lower or intermediate level of ABC, enjoy any productivity gains.

Third, we control for potential effects of exports, foreign ownership and import intensity in the underlying relationship between importing and productivity. Our findings confirm the dominance of imported intermediates over exports and foreign ownership in terms of furthering firm-level productivity.

The remainder of the paper is set out as follows. The next section presents the simple theoretical model, empirical specifications and description of data with measures. The major findings and robustness checks are discussed in Section 3, while in the final section we summarise the findings with policy implications for Ghana.

2. Model, empirical specification, and data

2.1. Model

We adopt a standard production function framework. The output of a firm depends on its use of inputs and on the level of technology employed as follows:

$$Q_{it} = A_{it} K_{it}^{\alpha_k} L_{it}^{\alpha_s} L_{it}^{\alpha_u} M_{it}^{\alpha_m} e^{\Omega_{it}} \quad (1)$$

where it index firm and time period; Q represents the output; A is the technology level, K is capital; L^s and L^u are the number of skilled and unskilled workers; M denotes intermediate materials and Ω denotes a productivity shock. From equation (1), total factor productivity (TFP) is measured as follows:

$$TFP_{it} = \frac{Q_{it}}{K_{it}^{\alpha_k} L_{it}^{\alpha_s} L_{it}^{\alpha_u} M_{it}^{\alpha_m}} \quad (2)$$

Alternatively, TFP can be expressed as the multiplication of an index of productivity potential, A_{it} , and an exogenous shock, $e^{\Omega_{it}}$:

$$TFP_{it} = A_{it} e^{\Omega_{it}} \quad (3)$$

Convergence is an essential idea in the recent literature on economic growth and technology transfer (Griffith, Redding, & Reenen, 2004; Madsen, 2007; Rodrik, 2014). We model the level of technology achieved by a firm as a function of its prior achievements and on its ability to converge on the technology frontier with:

$$A_{it}/A_{it-1} = [A_t^*/A_{it-1}]^{\alpha_{it}}, \quad 0 \leq \alpha_{it} \leq 1 \quad (4)$$

where A_t^* is a measure of the frontier technology at time t and α_{it} measures the speed of adjustment towards the frontier for the i th firm at time t .

We draw on the theory and findings of the prior literature in modelling convergence ability as a function of a firm's absorptive capacity and its use of imported intermediates that embody technology transfer. Using a linear function as a first-order approximation, yields a function as follows:

$$\alpha_{it} = \alpha_0 + \alpha_z z_{it} + \alpha_m m_{it}^f, \quad (5)$$

where z_{it} is a proportional measure of absorptive capacity ($0 \leq z_{it} \leq 1$) and m_{it}^f is a measure of the proportion of intermediate inputs that are imported ($0 \leq m_{it}^f \leq 1$). A strong assumption to ensure that α_{it} lies between zero and one regardless of the level of absorptive capacity or imported intermediates is that each coefficient in Equation (5) lies between zero and one and that the sum of coefficients in the equation is less than or equal to one. In practice, much weaker restrictions can be applied by checking that α_{it} has a positive value less than one for the actual values of z or m for each firm in a particular year.

Commonly used measures of absorptive capacity, z_{it} , are inputs that are thought to contribute to the productive use of technology embodied in imported intermediate goods, such as the proportion of skilled labour (Augier et al., 2013; Yasar, 2013). Instead, we measure the firm's absorptive capacity by its past success in improving its productivity relative to the initial level of productivity. We argue that firms whose productivity has grown by the most relative to their initial levels of productivity are those in the best position to make use of further advances in technology that are embodied in imported intermediate inputs.

This approach shifts the focus to viewing absorptive capacity as a dynamic characteristic of the firm rather than a static element of its production structure. Here, we follow the literature on dynamic capabilities as in Dosi, Nelson, and Winter (2001), which builds on Penrose's (1995) seminal contribution to the theory of the growth of firm. The basic idea is that managerial capability of the firm grows over time as experience leads to learning better ways to do things. While the approach has been mostly been applied in studies of firms in

advanced industrial economies, the idea seems particularly relevant to the circumstances of firms in developing economies with the substantial gulf between the typical firm's current technology and the world frontier.

Our measure of absorptive capacity is the ratio of the firm's lagged productivity to its initial productivity. The measure is lagged to avoid a spurious relationship with current productivity. Also, to construct a variable with an expected range from zero to no more than one, we take the natural logarithm of the productivity ratio. For any given period, z is defined as the natural logarithm of a firm's TFP in the prior period relative to the firm's initial TFP.³ An alternative measure of absorptive capacity considers real value added per worker in lieu of TFP. The two measures of absorptive capacity are positively and significantly correlated, suggesting that they can be used interchangeably.⁴ Denoting the initial TFP in firm i by TFP^*_{i0} , the TFP in firm i in the prior period by TFP_{it-1} , the initial value added per worker in firm i by LP^*_{i0} , and value added per worker in firm i in the prior period by LP_{it-1} , the ABC of firm i can be expressed as:

$$\text{Ln ABCTFP}_{it-1} = \text{Ln} \left[\frac{TFP_{it-1}}{TFP^*_{i0}} \right] = z_{it} \quad \text{or alternatively as} \quad \text{Ln ABCLP}_{it-1} = \text{Ln} \left[\frac{LP_{it-1}}{LP^*_{i0}} \right] = z_{it}$$

where Ln signifies natural logarithm.

Equation (5) implies that a firm that has access to more intermediate inputs from international sources is more likely to benefit from international technology spillovers. It also captures the effect of absorptive capacity in terms of enhancing, if any, the capacity of a firm to identify, adapt and absorb new outside technologies to raise productivity. To test whether the productivity impact of imported intermediates depends on the firms' absorptive capacity, Equation (5) is extended by incorporating an interaction term as below:

$$\alpha_{it} = \alpha_0 + \alpha_z z_{it} + \alpha_m m_{it}^f + \alpha_{mz} z_{it} m_{it}^f \quad (6)$$

³ We assume that the initial value is the TFP of firm i when first observed in the sample.

⁴ The correlation between the two measures of absorptive capacity is 0.94.

Equation (6) suggests that productivity is positively related to the proportion of imported intermediates employed in the production process, absorptive capacity and the joint effect of the imported intermediates and absorptive capacity. Firms with higher levels of absorptive capacity, measured by lagged relative productivity, have the potential to improve productivity by absorbing external technologies embodied in imported intermediates.

2.2. Empirical specification

Following the above theoretical framework, we specify a Cobb-Douglas production function for empirical purposes as follows:

$$\ln Y_{ijt} = \beta_0 + \beta_K \ln K_{ijt} + \beta_s \ln l_{sijt} + \beta_u \ln l_{uijt} + \lambda_t + \Omega_{ijt} + \eta_{ijt} \quad (7)$$

where the ijt subscript is firm, industry and time period; and the prefix $\ln$ on a variable name indicates the natural logarithm. Y denotes value added, K is capital input, l_s and l_u are skilled and unskilled labour inputs, λ is a year specific effect, Ω is a serially correlated productivity shock. The parameters β 's are to be estimated and η is an i.i.d shock.

Equation (7) is estimated according to industries covered in our sample. The industries are bakery, food and alcohol, furniture, chemicals, garments and textiles, machines, metal products, small-scale resource intensive industry (SSRII) and wood products. The ordinary least squares estimation (OLS) is not appropriate in the presence of correlation between unobserved productivity shocks and input decisions as reported in Kasahara and Rodrigue (2008).

To address this endogeneity issue, Equation (7) is estimated using the semi-parametric procedure proposed by Levinsohn and Petrin (2003). This procedure allows us to use intermediate inputs, such as energy or materials, to control for the correlation between input levels and the unobserved firm-specific productivity shocks.⁵

⁵ This approach corrects the simultaneity bias resulting from firms choosing their levels of inputs use once they know their levels of productivity. For a sensitivity check, OLS is used to estimate Equation 7.

TFP obtained from the first-stage regression is assumed to depend on the firm's level of technology and a productivity shock as specified in Equation (3) and the expression for its technology level as specified in Equation (4) and the adjustment coefficient as specified in Equation (6). Combining these expressions and taking natural logarithms yields:

$$\text{Ln TFP}_{ijt} - \text{Ln TFP}_{ijt-1} = (\alpha_0 + \alpha_z z_{it} + \alpha_m m_{it}^f + \alpha_{mz} z_{it} m_{it}^f)(\text{Ln } A_t^* - \text{Ln TFP}_{ijt-1}) + \Omega_{it} - \Omega_{it-1} \quad (8)$$

where TFP denotes total factor productivity at the firm level. We normalise this expression by assuming that $\text{Ln } A_t^*$ equals one, at least in the base year.⁶ We also simplify by dropping the second-order terms in lagged productivity on the right-hand side of Equation (8), which can then be restated as an expression for the log difference in TFP in which we also decompose the difference in productivity shocks into time, industry, location and firm-specific components:

$$\text{Ln TFP}_{ijt} - \text{Ln TFP}_{ijt-1} = (\alpha_0 + \alpha_z z_{it} + \alpha_m m_{it}^f + \alpha_{mz} z_{it} m_{it}^f) + \phi_i + \lambda_t + \Gamma_j + \kappa_l + u_{ijt} \quad (9)$$

where ϕ is a firm-specific effect; λ is a time-specific effect to account for macroeconomic shocks that are common to all firms, such as changes in the world technology frontier, government policies and exchange rates; Γ is an industry-specific effect; κ is a location-specific effect; and u is an i.i.d error. Finally, we also estimate the relationship in levels to avoid the possible loss of information in differencing with the logarithm of lagged productivity transferred to the right-hand side as follows:

$$\text{Ln TFP}_{ijt} = \gamma \text{Ln TFP}_{ijt-1} + (\alpha_0 + \alpha_z z_{it} + \alpha_m m_{it}^f + \alpha_{mz} z_{it} m_{it}^f) + \phi_i + \lambda_t + \Gamma_j + \kappa_l + u_{ijt} \quad (10)$$

A value of γ in Equation (10) less than one indicates that a firm does not automatically retain all of its prior productivity gains and can reflect the reduced prospect for catch-up as a firm gets closer to the technology frontier as shown in Equation (4).

⁶ Movement of the world technology frontier would lead to changes in the value of A_t^* , which have been modelled by Kneller and Stevens (2006) as due to the rise in world knowledge stocks. We leave world knowledge stocks out of our empirical analysis on the basis that movements in individual firm TFP in Ghana are likely to be dominated by firm-level variables. Instead, the influence of any change in the world technology frontier is treated as part of the time-specific effect, λ_t , that affects all firms (see Equation (9)).

A positive point estimate of α_m provides direct firm-level evidence of international technology spillovers arising from the utilisation of imported intermediates contemporaneously. If $\alpha_z = 0$, the productivity differential between importing and non-importing firms is captured by the point estimate of α_m . The point estimate α_z represents the productivity effect of absorptive capacity for non-importing firms. The productivity impact of imported intermediates augmented by the productive contribution of absorptive capacity can be measured as $\partial \ln \text{TFP}_{ijt} / \partial m_{it}^f = \alpha_m + \alpha_{mz} z_{it}$, while the productivity impact of absorptive capacity augmented by the productive contribution of imported intermediates can be captured by $\partial \ln \text{TFP}_{ijt} / \partial z_{it} = \alpha_z + \alpha_{mz} m_{it}^f$.

2.3. Overview of the data and measures

The empirical analysis is carried out using data from the World Bank Regional Project on Enterprise Development (RPED). The dataset is available from the Centre for the Study of African Economies (CSAE), at the University of Oxford. It is a panel survey of Ghanaian manufacturing firms over the period from 1991 to 2002.

The sample was drawn randomly from firms included in the 1987 Census of Manufacturing Activities. The firms covered are from major manufacturing hubs in Ghana, such as Accra, Cape Coast, Kumasi and Takoradi. The industries represented are Bakery, Food and Alcohol, Furniture, Chemical, Garments, Textiles, Machines, Small-scale Resource Intensive Subindustry, Metal Products and Wood Products, at the four-digit level following the International Standard of Industrial Classification (ISIC). Over the course of the data collection, close to half of the original sample firms were covered in each round of the survey. Firms that exited from the sample were replaced by new firms to keep the sample at a similar

size over the period covered. The replacements were based on size category, industry and location (see Regional Project on Enterprise Development, 2011).⁷

The data set contains a sizeable number of firms over a relatively long period with information on a wide range of firm and worker characteristics. It also includes pre-calculated firm-specific input, output deflators and deflated monetary variables. All monetary variables have been deflated using firm-level specific price indices. Questions pertaining to earnings refer to the time of the survey in the case of worker-level information, whereas firm-level information refers to the previous calendar year. This allows deflating of the variables based on time differences in information given that inflation was considerable during the period of our analysis (see Regional Project on Enterprise Development, 2011). The final dataset is an unbalanced panel with a total of 1692 observations.

The seminal paper of Olley and Pakes shows that selection issues arise with the use of balanced panels compared to unbalanced panels. They demonstrate that selection correction matters for results generated using a balanced panel, whereas, results generated using an unbalanced panel are not susceptible to the selection problem (See Levinsohn & Petrin, 2003). The sample used in the study is unbalanced, thus, making it possible to abstract from addressing selection issues.

We consider real valued-added as a measure of output (Y). Labour is measured by the number of skilled (L^S) and unskilled (L^U) workers or the total number of workers (L). Capital (K) is measured by total physical capital (real replacement value of plant and machinery). Raw materials (M) are measured using real cost of materials. Import status (DIC) is a dummy

⁷ This method of sampling design potentially introduces some bias in the results as the sample is not refreshed with an appropriately chosen sub-sample of entering firms. The bias is to some extent mitigated in that the entering and exiting firms are smaller than the average firms. As a result, the replacement firm is on average smaller than average as is the exiting firm. Similar to Frazer (2005), we do not have any information on the pool of entering firms, thus, the size of the bias cannot be determined a priori.

that takes the value 1 if a firm purchases any intermediate inputs from abroad in time t and 0 otherwise. Import intensity (IMT) is measured using the ratio of real expenditure on imported intermediates to total real expenditure on intermediate inputs. Export status (EXP) is a dummy equal to 1 if a firm exports any products in time t and 0 otherwise. Foreign direct investment (FDI) intensity is measured by real value added multiplied by the percentage of foreign ownership in firm i divided by the total real value added by industries.

Insert Table 1 around here

Table 1 presents the summary statistics in terms of the average characteristics of importing and non-importing firms.⁸ A test for equality of means shows that the differences between importing and non-importing firms are statistically different from zero for all considered variables except the export status.⁹ Preliminary evidence based on the unconditional means of indicators of productivity, such as, value added, TFP, and labour productivity suggests that importing firms tend to be more productive than non-importing firms.¹⁰ Potential productivity gains derived from the use of foreign inputs may help to explain this difference.

Importing firms tend to be more capital intensive, more likely to use more raw materials or employ more skilled or unskilled workers than non-importing firms. They also tend to be older and are more likely to have foreign presence. Based on the measure of import intensity, the share of foreign inputs used in the production processes is about 35 percent and for any given period, about 43 percent of firms used imported intermediates in any year over the sample period. In general, a sizeable number of firms in the sample utilise imported intermediates and are thus potentially well positioned to absorb international technology spillovers.

⁸ With reference to the summary statistics, a firm is defined as importing if it has purchased any intermediates from abroad over the sample period and otherwise classified as non-importing firm.

⁹ The test excludes import status, import intensity and firm size. The test for FDI intensity is based on the assumption of unequal variances. The results for other variables hold under the assumption of equal or unequal variances.

¹⁰ The key measure of productivity used in this paper is TFP, other indicators of productivity are used as alternative measures of productivity.

Insert Figures 1 to 4 around here

Figures 1 to 4 present graphical comparisons of alternative measures of ABC against measured productivity. In Figure 1, ABC is measured by lagged relative productivity ($ABCTFP_{t-1}$). The fitted line for importing firms is relatively steeper than that of non-importing firms. This provides further support that importing firms are potentially better equipped to absorb new external technology to enhance productivity.¹¹

In Figure 2, ABC is measured by the ratio of TFP in firm i in the previous period to the maximum level of TFP of a frontier firm within the industry ($ABCFR_{t-1}$), similar to previous studies (Girma, 2005; Minjung, 2015). ABC measured by the distance of the firm from the frontier firm ($ABCFR_{t-1}$) potentially captures whether there is convergence in TFP towards the technological frontier (Griffith, Redding, & Simpson, 2002). As with the ($ABCTFP_{t-1}$) measure the fitted line for importing firms is steeper than that of non-importing firms.

In Figure 3, ABC is measured by the lagged share of skilled workers in total employment ($PSKILL_{t-1}$), similar to Yasar (2013). ABC in Figure 4 is measured by the lagged firm average of years of education (EDU_{t-1}). ABC measured by either $PSKILL_{t-1}$ or EDU_{t-1} tends to be correlated with firm-specific time invariant factors (Söderbom & Teal, 2004). The proxies for ABC, as shown in Figures 3 and 4, show no noticeable difference in the absorptive capacity of importing and non-importing firms and the fitted lines show no noticeable slope. These commonly used measures of absorptive capacity show no clear association with increased productivity for either importing or non-importing firms.

Insert Tables 2 and 3 around here

¹¹ Given the data limitation resulting from the replacement of exiting firms, it may be argued that similar firms enter the sample at different ages. This may make it unclear how two observations of absorptive capacity are comparable across firms in a given year without additional controls for the firm age at which initial TFP is set. Frazer (2005) shows that the difference between the average age of exiting and surviving firms is not significantly different from zero. By extension, it is unlikely that there is a significant difference between the average age of exiting and entering firms. In light of the apparent similarities between exiting and entering firms, we argue that observations of absorptive capacity are comparable across exiting and entering firms in a given year without additional controls for the firm age at which initial TFP is set.

Table 2 reports the correlations between different measures of firm performance and measures of ABC. ABC measured by $ABCTFP_{t-1}$ or $ABCLP_{t-1}$ is positively correlated with value added, labour productivity or TFP. ABC measured by $PSKILL_{t-1}$ seems to be a particularly poor proxy for ABC. Preliminary evidence, as shown in Table 2, suggests that there is no significant correlation between $PSKILL_{t-1}$ and TFP. As reported in Table 3, tests for multicollinearity show no signs of severe multicollinearity.¹²

3. Empirical Findings

3.1. OLS Results

The OLS parameter estimates for our model are presented in columns 1 to 4 of Table 4. As reported in columns 1 to 4, there is no strong evidence that firm age or the contemporaneous or prior use of imported intermediates (DIC_t or $DIC_{t-1} = 1$), is associated with productivity improvement. This suggests that firms generally do not necessarily improve productivity from the use of imported intermediates or become more productive as they get older.

As shown in columns 1 to 4, absorptive capacity is negatively associated with productivity growth for non-importing firms, with estimated coefficients for $\ln ABCTFP_{t-1}$ and $\ln ABCLP_{t-1}$ ranging from -0.26 to -0.28. It appears that non-importing firms are less equipped to further productivity growth from international technology spillovers. However, the estimated coefficients of the interaction between ABC and DIC are uniformly positive and statistically significant, with coefficients ranging from 0.12 to 0.19. Combining these effects, the link between ABC and productivity growth appears to be negative for importing firms, though less negative compared to non-importing firms (the combined impact ranges from -0.14 to -0.09 for importing firms versus -0.26 to -0.28 for non-importing firms).

Insert Table 4 around here

¹² The “rule of thumb” in the econometric literature is that a VIF greater than 10 or a tolerance level less than 0.1 is a sign of a severe multicollinearity problem.

The estimated parameter of the interaction term indicates how much additional increase in lagged relative productivity augments the productive contribution of imported intermediates. The effect of lagged relative productivity is positive and statistically significant when interacted with either contemporaneous or lagged use of imported intermediates. As shown in columns 1 and 2, a one percent change in lagged relative productivity, as measured by the two measures of ABC, augmented by the productive contribution of current imported intermediates (DIC_t), is associated with a 0.12 percent increase in productivity growth. This implies that manufacturing firms with high levels of absorptive capacity are better able to improve productivity from the current use of imported intermediates.

The estimates for past import activity are also consistent with the notion that firms with the requisite levels of absorptive capacity tend to benefit from the use of imported intermediates. As shown in columns 3 and 4, the potential association between lagged relative productivity augmented by lagged imported intermediates, rises to around 0.18 to 0.19 percent change in productivity growth.

Results obtained using lagged relative labour productivity in place of lagged relative TFP are qualitatively similar. This confirms our initial expectations that the two variables can be used interchangeably. In view of the strong positive correlation between the two measures, lagged relative TFP, as measured by $\ln ABCTFP_{t-1}$, is used in the remaining estimations.

Overall, results from the OLS parameter estimates, as reported in columns 1 to 4 of Table 4, show that contemporaneous and prior use of imported intermediates is positively associated with productivity growth only when firms have high levels of absorptive capacity. However, the OLS estimates are likely to be biased due to the potential self-selection of more productive firms into import markets. They are also more likely to be biased due to the potential endogeneity of some variables used in the estimations. This is going to be the case if firms improve in their absorptive capacity in anticipation of future performance, or if

unobserved heterogeneity is present in the import variable or lagged relative productivity and performance equations. To tackle this problem, we re-run the regressions using the fixed-effects estimator, which addresses potential endogeneity issues arising from permanent firm-specific effects and firms' decisions.

3.2. Fixed-effects results

The parameter estimates obtained using the fixed-effects estimator are presented in columns 5 and 6 of Table 4. In general, the estimates are consistent with the ones obtained using OLS, particularly in terms of direction. After controlling for endogeneity arising from unobserved firm-specific effects, the parameter estimates appear to differ slightly from the OLS estimates in two ways.

First, the association between ABC and productivity growth for non-importing firms becomes more negative. Second, there is a slight increase in the impact of ABC augmented by both the current and the past import activities. In general, these results confirm that the productivity gains from the current and past use of imported intermediates are more likely to be enjoyed by firms with high levels of absorptive capacity. Fixed-effects estimates, however, are not robust against potential endogeneity between inputs and persistence shocks that varies across firms over time.

The panel dimension of the data is used to correct for potential endogeneity issues using System GMM. A lag length of 3 is used for variables as instruments in the first-differenced equations and a lag length of 1 in the level equations.¹³ GMM instruments are used for the lagged dependent variable. The validity of the instruments is tested by the Hansen test of over-identifying restrictions. Failure to reject the null hypothesis of the Hansen test gives support to our model. The estimated models satisfy the absence of second-order autocorrelation in the residuals.

¹³ The estimates obtained using a lag length of 3 and 4 for results reported in Table 5 are qualitatively similar in terms of direction and significance. They are not reported, but are available upon request from the authors.

3.3. System GMM results

The parameter estimates obtained using two-step system GMM are presented in columns 1 and 2 of Table 5. The point estimates yield some interesting results. Parameter estimates of the contemporaneous and the lagged effects of imported intermediates for a firm with no absorptive capacity are consistent with the ones obtained using OLS and fixed-effects estimators. Also, the estimates confirm that lagged relative productivity has a negative impact on productivity for non-importing firms.

Insert Table 5 around here

As shown in the first and second columns of Table 5, after controlling for potential endogeneity using System GMM estimator, the point estimates indicate that absorptive capacity has a positive impact on productivity for importing firms. In general, importing firms register relative improvement in productivity compared to non-importing firms. Specifically, as reported in columns 1 and 2 of Table 5, a one percent change in lagged relative productivity leads to a 0.07 percent change in productivity with respect to current import activity, whereas it is a 0.20 percent change in productivity with respect to past import activity. Similarly, as shown in columns 1 and 2 of Table 5, a one percent change in ABC augmented by the productive contribution of current import activity leads to a 0.32 percent change in productivity, whereas it is a 0.49 percent in productivity with respect to past import activity.

A more traditional measure of ABC is the distance of the firm from the frontier, which we denote by $ABC_{FR,t-1}$. To check how our new proposed measure of ABC compares to this traditional measure, we re-run regressions base models using absorptive capacity measured by $ABC_{FR,t-1}$. In general, the estimates of absorptive capacity or the interaction between absorptive capacity ($ABC_{FR,t-1}$) and import variable are mostly insignificantly different than zero. However, the

results are qualitatively similar in terms of direction. This suggests that $ABCFR_{t-1}$ is potentially a weaker proxy for absorptive capacity than our preferred measure.¹⁴

For a sensitivity check as it relates to the measure of productivity from our first-stage regressions, we re-run the model specifications using TFP obtained using the OLS estimator in lieu of the one obtained using the semi-parametric procedure proposed by Levinsohn and Petrin (2003). The estimates obtained were qualitatively similar in terms of direction and significance. In general, however, the magnitudes of most of the estimates were higher relative to the ones reported.¹⁵

Given the opposing signs on the interaction terms with the level variables, it may be argued that it is unclear whether the total impacts are significantly different from zero. To address this concern, we run a t-test on the sign of the combined coefficients. We use three plausible values of ABC, namely average the value of $\ln ABCTFP_{t-1}$, (0.21), a high value of $\ln ABCTFP_{t-1}$, (3.82), and a very high value of $\ln ABCTFP_{t-1}$, (4.50) to test the hypothesis for a positive impact of imported intermediates on TFP growth. The null and alternative hypotheses with current imported input intensity are:¹⁶

H_0 : [Coefficient of DIC_t] + [Coefficient of $DIC_t * \ln ABCTFP_{t-1}$] * $\ln ABCTFP_{t-1}$ (one of the plausible values of ABC) = 0

H_1 : [Coefficient of DIC_t] + [Coefficient of $DIC_t * \ln ABCTFP_{t-1}$] * $\ln ABCTFP_{t-1}$ (one of the plausible values of ABC) $\neq$ 0

The results, which are presented in Table 6, show that firms with at least high absorptive capacity increase their TFP growth by statistically significant amounts through the use of imported intermediates.

¹⁴ The difficulty may be that the industry leader in the Ghanaian industry is not close to the world technology frontier. Therefore, the measure of absorptive capacity for the leading firm is misstated and changes in its position introduce noise into the measurement of absorptive capacity for other firms. The results with the $ABCFR_{t-1}$ measure are not reported for the sake of space economy, but are available from the authors upon request.

¹⁵ The results are not reported to conserve space.

¹⁶ In tests for null and alternative hypotheses in other models, the coefficient of lagged import intensity variable replaces that of current import intensity and the coefficient of $\ln ABCLP_{t-1}$ replaces that of $\ln ABCTFP_{t-1}$.

Insert Table 6 around here

Overall, the results suggest that a certain level of absorptive capacity needs to be achieved before a firm can absorb technologies embodied in imported intermediates to obtain a substantial boost in productivity. This finding is consistent with the theoretical rationale of this study in that the productivity enhancing effect of imported intermediates depends strongly on a firm's absorptive capacity. The significant positive estimated parameters of the interaction between imported intermediates and lagged relative productivity suggest that they are complementary.¹⁷ This is line with the existence of technology-skill and capital-skill complementarities in the manufacturing (Galor & Moav, 2000; Goldin & Katz, 1998), especially in the context of SSA.

Firms that register continuous improvement in productivity are better equipped to absorb technologies embodied in imported intermediates to boost productivity. A firm can improve on its absorptive capacity through learning from manufacturing operations, continual investments in human resource development, internal R&D activities, or acquiring R&D from external sources. The use of imported intermediates alone is not enough for a firm to further its productivity. A firm needs to possess a high level of absorptive capacity in order to capture international technology spillovers embodied in imported intermediates and, in turn, boost productivity.

3.4. Empirical findings by industry

To examine whether the productivity impact of imported intermediates augmented by ABC is industry dependent, the industries covered in the study are categorised into two groups. The

¹⁷ As argued by Akerberg, Caves, and Frazer (2015), TFP estimated using Levinsohn and Petrin (2003) proxy estimator has a number of identification problems. To test the robustness of the our results, we re-run all the base models using TFP obtained using the modified version of Levinsohn and Petrin (2003) proxy estimator (WLP) proposed by Wooldridge (2009). It corrects for the simultaneous determination of inputs and productivity. It does not impose constant returns to scale (Nishida, Petrin, & White, 2015; Petrin & Levinsohn, 2012). The approach is robust to the Akerberg et al. (2015) criticisms. TFP estimated using WLP is strongly positively correlated (0.88) with the one estimated using the method proposed by Levinsohn and Petrin (2003). In general, the results obtained using TFP estimated based on WLP approach are similar in terms of direction, magnitude and significance. They are not reported here, but are available from the authors on request.

groups are separated by the mean value of the interaction between import intensity and lagged relative productivity of all firms in that industry. The industries with higher than average values of the interaction term include machines, metals, and chemicals. The industries with lower than average values of the interaction term include alcohol, bakery, furniture, textile, wood, food, garment and small-scale resource intensive industry.¹⁸

The parameter estimates of the link between imported intermediates, absorptive capacity and productivity based on industry categorization are presented in Table 7. The estimates are obtained using the system GMM (two-step) with the log of TFP as the dependent variable. The parameter estimates in columns 1 and 3 show no strong evidence that the use of imported intermediates leads to productivity gains for firms operating in low input-absorptive intensive industries, even when augmented by ABC. This finding holds for both the contemporaneous and past effects of imported intermediates. Firms operating in low input-absorptive intensive industries use a smaller share of foreign inputs, in addition to possessing lower levels of absorptive capacity. They are, thus, less-equipped to absorb international technology spillovers over time.

Insert Table 7 around here

Interestingly, the positive and statistically significant estimated coefficient of the interaction between imported intermediates and lagged relative productivity for firms in the high interaction variable industries (columns 2 and 4) reinforces the notion that the productivity effect of imported intermediates depends on a high level of ABC. Firms operating in the machines, metals, and chemicals use a larger share of imported intermediates, in addition to exhibiting high levels of absorptive capacity so they are better placed to absorb technologies embodied in imported intermediates to boost productivity than firms in other sectors. This finding is consistent with the notion that machines, chemicals and metal

¹⁸ The mean value of the interaction term for all firms covered in the sample is 0.097, 0.283 for industries classified as having a high interaction variable value and 0.026 for industries having a low value.

products or equipment are the industries at the forefront of the increase in vertical specialisation of international trade, where firms use imported intermediates to produce goods or services for domestic consumption or for export (Hummels, Rapoport, & Yi, 1998; Kleinert, 2003).

3.5. Robustness checks

We consider several additional robustness checks by controlling for exporting, foreign ownership, and by using import intensity in lieu of an import dummy. Table 8 presents parameter estimates of the robustness checks.

Insert Table 8 around here

Export market participation may lead to productivity benefits. The robustness of the findings to exporting is tested by running regressions in which export status is controlled for. Export has a positive impact on productivity, but is only weakly statistically significant in one of the estimations (in column 2). Similarly, the productive contribution of imported intermediates augmented by ABC may capture some of the productivity effect of foreign ownership or foreign direct investment (FDI). The effect of foreign presence is controlled for using a measure of FDI intensity. Foreign presence has a positive impact on productivity, though its effect is never highly statistically significant.

The significant positive contribution of imported intermediates augmented by ABC remains after controlling for the potential effect of export market participation or foreign presence. These results hold for both contemporaneous and past use of imported intermediates augmented by the productive contribution of lagged relative productivity.

In addition, we examine the potential effect of the intensity of the firm's use of imported intermediates by using an import intensity variable in lieu of import status. The parameter estimates are qualitatively similar to earlier results in which import status is used. In general, the parameter estimates are robust to changes in the regression specification.

4. Conclusion

The Ghanaian manufacturing sector is not operating close to full potential. A number of development schemes are in place aimed at increasing competitiveness and productivity.¹⁹ Trade, innovation and technology are broad policy areas under the new industrial plan introduced in 2011. Our research shows that international access to foreign inputs is one of the channels of enhancing productivity. High levels of absorptive capacity help firms to benefit from technologies embodied in foreign inputs to further productivity. We propose lagged relative productivity as a new proxy for absorptive capacity and find that this proxy interacts with the use of imported intermediates to have a positive and statistically significant impact on productivity growth and productivity levels. This proxy is found to have superior explanatory power than the commonly used measures of ABC.

In addition, we show that the productivity impact of imported intermediates augmented by lagged relative productivity is industry specific. In general, firms in specialised imported input intensive industries, such as machinery, have high levels of absorptive capacity and are better positioned than other industries to enjoy productivity gains from the use of imported intermediates.

The findings of this paper have important policy implications for a developing country like Ghana. A targeted tariff concession that creates an enabling environment for firms to source higher quality foreign intermediates at subsidised rates in industries such as chemical, machinery and metal products can help in promoting productivity and international competitiveness. Policies aimed at improving absorptive capacity of firms from various sources, for example, continual investment in human resource development and subsidised research and development are important tools for boosting international competitiveness and productivity.

¹⁹ For more information (see Killick, 2010)

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Comparison: Different indicators of absorptive capacity

Figure 1: Ln ABCTFP_{t-1}

Figure 2: ABCFR_{t-1}

Notes: Ln ABCTFP_{t-1} denotes lagged relative productivity; ABCFR_{t-1} is the ratio of a firm's lagged TFP to the maximum level of TFP within the industry; all variables are demeaned. A firm is defined as importing if it purchased any intermediate inputs from abroad over the sample period and non-importing otherwise.

Figure 3: PSKILL_{t-1}

Figure 4: EDU_{t-1}

Notes: PSKILL_{t-1} denotes lagged share of skilled workers in total employment; EDU_{t-1} is lagged firm average of years of education; all variables are demeaned. A firm is defined as importing if it purchased any intermediate inputs from abroad over the sample period and non-importing otherwise.

Table 1: Summary statistics

Variables	Non-importing firms	Importing firms	All firms
Ln value added	15.43 (2.10)	16.55 (2.30)	16.27 (2.31)
Ln capital	15.04 (2.93)	16.63 (3.07)	16.24 (3.11)
Ln labour	2.85 (1.36)	3.38 (1.36)	3.25 (1.38)
Ln unskilled labour	2.60 (1.45)	3.09 (1.41)	2.97 (1.43)
Ln skilled labour	1.05 (1.39)	1.62 (1.49)	1.48 (1.49)
Ln raw materials	15.89 (2.08)	16.72 (2.24)	16.52 (2.23)
Age	17.14 (14.17)	18.64 (11.68)	18.26 (12.36)
Import status	0.00 (0.00)	0.57 (0.49)	0.43 (0.50)
Import intensity	0.00 (0.00)	0.35 (0.39)	0.26 (0.37)
Ln labour productivity	12.57 (1.30)	13.17 (1.39)	13.02 (1.39)
Ln TFP	6.96 (4.95)	9.95 (6.40)	9.21 (6.21)
TFP growth	-0.16 (1.10)	0.01 (0.88)	-0.03 (0.94)
Ln ABCTFP _{t-1}	-0.05 (1.11)	0.28 (1.14)	0.21 (1.14)
Ln ABCLP _{t-1}	-0.03 (1.04)	0.26 (1.11)	0.19 (1.10)
FDI intensity	0.06 (0.52)	0.16 (1.30)	0.13 (1.15)
Export status	0.35 (0.48)	0.32 (0.47)	0.33 (0.47)
Observations	418	1274	1692

Notes: The figures without parentheses are means, while figures in parentheses are standard deviations. All monetary variables are in real Ghana cedis. Ln denotes logarithm; TFP is total factor productivity; ABCTFP_{t-1} is lagged relative TFP and ABCLP_{t-1} is lagged relative labour productivity.

Table 2: Correlation matrix of key variables

Variable	Ln VA _t	Ln LP _t	Ln TFP _t	Ln ABCTFP _{t-1}	Ln ABCLP _{t-1}	Ln ABCFR _{t-1}	PSKIL _{t-1}
Ln VA _t	1						
Ln LP _t	0.84***	1					
Ln TFP _t	0.12***	0.28***	1				
Ln ABCTFP _{t-1}	0.13***	0.22***	0.27***	1			
Ln ABCLP _{t-1}	0.12***	0.23***	0.19***	0.94***	1		
Ln ABCFR _{t-1}	0.09**	0.26***	0.57***	0.30***	0.27***	1	
PSKIL _{t-1}	0.11***	0.25***	-0.01	-0.06*	0.01	-0.06*	1

Notes: Ln VA_t denotes log real value added; Ln LP_t stands for log labour productivity; Ln TFP_t is log total factor productivity; Ln ABCTFP_{t-1} is lagged relative productivity; Ln ABCLP_{t-1} is lagged relative labour productivity; Ln ABCFR_{t-1} is the lagged ratio of TFP in firm *i* to the maximum level of TFP within the firm's industry and PSKIL_{t-1} stands for the share of skilled workers in the firm's total employment. Significance at p<0.05, p<0.01 and p<0.001 is indicated by *, ** and ***. Source: Author's calculations based on data from surveys of Ghana manufacturing firms.

Table 3: Tests of multicollinearity: variance inflation factors (VIF) and tolerance

Dependent variable: TFP growth				
	VIF	Tolerance	VIF	Tolerance
DIC _t	1.06	0.95	1.07	0.93
Ln ABCTFP _{t-1}	1.61	0.62	1.60	0.63
DIC _t * Ln ABCTFP _{t-1}	1.68	0.60	1.67	0.60
Firm age			1.02	0.98
Export dummy			1.01	0.99
FDI intensity			1.02	0.98
Mean VIF	1.45		1.23	

Notes: DIC_t is import status; Ln ABCTFP_{t-1} is lagged relative productivity. Results obtained using Ln ABCLP_{t-1} are qualitatively similar, but not reported for the sake of space economy.

Table 4: Import activities, absorptive capacity and productivity (OLS and FE)

Dependent variable: TFP growth: $\ln TFP_t - \ln TFP_{t-1}$

	(1)	(2)	(3)	(4)	(5)	(6)
Independent Variables	OLS	OLS	OLS	OLS	FE	FE
DIC_t	0.02	0.02			0.04	
	(0.05)	(0.05)			(0.07)	
$\ln ABCLP_{t-1}$		-0.26***		-0.28***		
		(0.05)		(0.04)		
$DIC_t * \ln ABCLP_{t-1}$		0.12**				
		(0.05)				
Firm age _t	-0.00*	-0.00	-0.00	-0.00		
	(0.00)	(0.00)	(0.00)	(0.00)		
$\ln ABCTFP_{t-1}$	-0.26***		-0.28***		-0.71***	-0.72***
	(0.05)		(0.05)		(0.06)	(0.06)
$DIC_t * \ln ABCTFP_{t-1}$	0.12**				0.17**	
	(0.05)				(0.07)	
DIC_{t-1}			-0.01	-0.01		0.05
			(0.05)	(0.05)		(0.07)
$DIC_{t-1} * \ln ABCLP_{t-1}$				0.18***		
				(0.05)		
$DIC_{t-1} * \ln ABCTFP_{t-1}$			0.19***			0.21***
			(0.05)			(0.06)
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects	Yes	Yes	Yes	Yes	No	No
Location Effects	Yes	Yes	Yes	Yes	No	No
Observations	1310	1310	1310	1310	1348	1348
R-Squared/R-Sq: Within	0.12	0.12	0.13	0.12	0.35	0.35

Notes: FE denotes fixed-effects estimator; Ln denotes natural logarithm; TFP is obtained using the semi-parametric procedure proposed by Levinsohn and Petrin (2003). ABCTFP denotes lagged relative productivity, ABCLP is an alternative proxy for ABC. DIC is import status, the numbers in parentheses in columns are robust standard errors. Significance at the 1 percent, 5 percent and 10 percent level is indicated by ***, ** and *. All regressions include a constant, but not reported.

Table 5: Import activities, absorptive capacity and productivity (System GMM)

Dependent Variable: Ln TFP

	(1)	(2)
Independent Variables	SYS-GMM	SYS-GMM
Ln TFP_{t-1}	0.73*** (0.09)	0.73*** (0.08)
DIC_t	-0.08 (0.20)	
Ln ABCTFP_{t-1}	-0.25*** (0.09)	-0.29*** (0.09)
$\text{DIC}_t * \text{Ln ABCTFP}_{t-1}$	0.32** (0.14)	
DIC_{t-1}		-0.04 (0.19)
$\text{DIC}_{t-1} * \text{Ln ABCTFP}_{t-1}$		0.49*** (0.16)
Year Effects	Yes	yes
Industry Effects	Yes	yes
Location Effects	Yes	yes
Observations	1348	1348
$\text{AR}(2)_{p\text{-value}}^1$	0.97	0.81
$\text{Hansen}_{p\text{-value}}^2$	0.30	0.29
No. of groups	234	234
Instrument count	130	128

Notes: SYS-GMM is system GMM (two-step); Ln denotes natural logarithm; ABCTFP denotes lagged relative productivity, ABCLP is an alternative proxy for ABC. DIC is import status. Significance at the 1 percent, 5 percent and 10 percent level is indicated by ***, ** and *. Hypothesis tests are based on robust, finite sample corrected standard errors calculated applying the method postulated by Windmeijer (2000). A lag length of 3 and 3 was used for the instruments in the first-differenced equations and a lag length of 1 in the level equations. GMM style instruments are used for lagged dependent variable in each of the estimations. 1. Tests the null hypothesis that the differenced residuals in periods t and $t - 2$ are uncorrelated. 2. Tests for the validity of the overidentifying restrictions. All regressions include a constant that is not reported.

Table 6: Test for a positive impact of imported intermediates on TFP growth

OLS, Column 1 of Table 4				OLS, Column 2 of Table 4			
Test	ABC=0.21	ABC=3.82	ABC=4.50	Test	ABC=0.21	ABC=3.82	ABC=4.50
$[DIC_t] +$ $[DIC_t *$ $Ln ABCTFP_{t-1}]$ $*$ $[Ln ABCTFP_{t-1}]$	0.04	0.48**	0.56**	$[DIC_t] +$ $[DIC_t *$ $Ln ABCLP_{t-1}] *$ $[Ln ABCLP_{t-1}]$	0.04	0.47**	0.55**
	(0.05)	(0.20)	(0.23)		(0.05)	(0.20)	(0.24)
Observations	1310	1310	1310	Observations	1310	1310	1310
OLS, Column 3 of Table 4				OLS, Column 4 of Table 4			
$[DIC_{t-1}] +$ $[DIC_{t-1} *$ $Ln ABCTFP_{t-1}]$ $*$ $[Ln ABCTFP_{t-1}]$	0.03	0.71***	0.84***	$[DIC_{t-1}] +$ $[DIC_{t-1} *$ $Ln ABCLP_{t-1}] *$ $[Ln ABCLP_{t-1}]$	0.03	0.69***	0.82***
	(0.05)	(0.19)	(0.23)		(0.05)	(0.19)	(0.23)
Observations	1310	1310	1310	Observations	1310	1310	1310
FE, Column 5 of Table 4				FE, Column 6 of Table 4			
$[DIC_t] +$ $[DIC_t *$ $Ln ABCTFP_{t-1}]$ $*$ $[Ln ABCTFP_{t-1}]$	0.08	0.70**	0.82**	$[DIC_{t-1}] +$ $[DIC_{t-1} *$ $Ln ABCTFP_{t-1}]$ $*$ $[Ln ABCTFP_{t-1}]$	0.09	0.86***	1.00***
	(0.07)	(0.28)	(0.33)		(0.06)	(0.22)	(0.26)
Observations	1348	1348	1348	Observations	1348	1348	1348

Notes: The numbers in parentheses in columns are standard errors. Significance at the 1 percent and 5 percent level are indicated by *** and **.

Table 7: Import activities, absorptive capacity and productivity by industries

Dependent variable: Ln TFP				
Independent Variables	(1)	(2)	(3)	(4)
	Alcohol, Bakery, Furniture, Textile, Food, Garment' SSRII & Wood	Machines, Metals & Chemicals	Alcohol, Bakery, Furniture, Textile, Food, Garment' SSRII & Wood	Machines, Metals & Chemicals
Ln TFP_{t-1}	0.79*** (0.08)	0.93*** (0.07)	0.76*** (0.12)	0.89*** (0.09)
DIC_t	-0.04 (0.18)	-0.56 (0.43)		
Ln ABCTFP_{t-1}	-0.17** (0.08)	-0.62*** (0.15)	-0.16* (0.09)	-0.57*** (0.11)
$\text{DIC}_t * \text{Ln ABCTFP}_{t-1}$	0.22 (0.15)	0.68** (0.26)		
DIC_{t-1}			-0.31 (0.27)	-0.09 (0.33)
$\text{DIC}_{t-1} * \text{Ln ABCTFP}_{t-1}$			0.20 (0.18)	0.61*** (0.19)
Year Effects	Yes	Yes	Yes	yes
Industry Effects	yes	Yes	Yes	yes
Location Effects	yes	Yes	Yes	yes
Observations	974	374	974	374
$\text{AR}(2)_{p\text{-value}}^1$	0.66	0.96	0.63	0.96
$\text{Hansen}_{p\text{-value}}^2$	0.59	0.12	0.59	0.15
No. of groups	168	66	168	66
Instrument count	96	63	89	61

Notes: Estimates obtained using System GMM (two-step). Ln denotes the natural logarithm. ABCTFP denotes relative productivity, ABCLP is an alternative proxy for ABC. DIC is import status, hypothesis tests in all the columns are based on robust, finite sample corrected standard errors calculated applying the method postulated by Windmeijer (2000). Significance at the 1 percent, 5 percent and 10 percent level is indicated by ***, ** and *. A lag length of 3 and 3 was used for the instruments in the first-differenced equations and a lag length of 1 in the level equations for results reported in column 1. A lag length of 8 and 8 was used in columns 2 and 4, whereas a lag length of 4 and 4 was used in column 3. A lag length of 3 and 2 was used for lagged dependent variable in each of the estimations. 1. Tests the null hypothesis that the differenced residuals in periods t and $t - 2$ are uncorrelated. 2. Tests for the validity of the overidentifying restrictions (Hansen). All regressions include a constant, but not reported.

Table 8: Robustness checks: Import activities, absorptive capacity and productivity

Dependent variable: Ln TFP				
Independent Variables	(1)	(2)	(3)	(4)
Ln TFP_{t-1}	0.77*** (0.07)	0.75*** (0.07)	0.80*** (0.07)	0.76*** (0.07)
DIC_t	-0.25* (0.15)			
Ln ABCTFP_{t-1}	-0.26*** (0.07)	-0.26*** (0.07)	-0.24*** (0.08)	-0.21*** (0.07)
$\text{DIC}_t * \text{Ln ABCTFP}_{t-1}$	0.34** (0.13)			
EXP_t	0.28 (0.17)	0.33* (0.17)	0.24 (0.17)	0.27 (0.17)
Firm age _t	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.01)
FDI Intensity	0.15* (0.09)	0.13 (0.08)	0.14 (0.09)	0.14 (0.09)
DIC_{t-1}		-0.02 (0.16)		
$\text{DIC}_{t-1} * \text{Ln ABCTFP}_{t-1}$		0.39*** (0.12)		
IMT_t			-0.22 (0.23)	
$\text{IMT}_t * \text{Ln ABCTFP}_{t-1}$			0.33** (0.17)	
IMT_{t-1}				-0.05 (0.21)
$\text{IMT}_{t-1} * \text{Ln ABCTFP}_{t-1}$				0.36** (0.18)
Year Effects	yes	yes	yes	yes
Industry Effects	yes	yes	yes	yes
Location Effects	yes	yes	yes	yes
Observations	1274	1274	1274	1274
$\text{AR}(2)_{p\text{-value}}^1$	0.82	0.97	0.73	0.79
$\text{Hansen}_{p\text{-value}}^2$	0.41	0.59	0.67	0.63
No. of groups	218	218	218	218
Instrument count	183	181	185	183

Notes: System GMM Results (two-step) reported. Ln denotes natural logarithm. ABCTFP denotes proxy for ABC, DIC is import status; IMT is import intensity; EXP is export status. Significance at the 1 percent, 5 percent and 10 percent level is indicated by ***, ** and *. Hypothesis tests are based on robust, finite sample corrected standard errors calculated applying the method postulated by Windmeijer (2000). A lag length of 3 and 3 is used for the instruments in the first-differenced equations and a lag length of 1 in the level equations. GMM style instruments are used for lagged dependent variable in each of the estimations. 1. Tests the null hypothesis that the differenced residuals in periods t and $t - 2$ are uncorrelated. 2. Tests for the validity of the overidentifying restrictions. All regressions include a constant, but not reported.