The Impact of China-Africa Trade on the Productivity of African Firms: Evidence from Ghana

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Abstract: Using firm- and industry-level panel data, this study investigates the impact of the Ghana-China trade on labour productivity of Ghanaian manufacturing firms and compares it to the impact induced by the trade of Ghana with the OECD. The main findings suggest that the productivity effect in Ghanaian manufacturing firms triggered by engaging in international trade activities is contingent upon the industrial competitive advantage and the trading partners. The empirical results show that trading with China creates greater potentials for Ghanaian manufacturing firms to raise productivity in comparison to trading with OECD countries. Higher intensities of imports from China stimulate productivity gains while more exports to China only enhance productivity in industries in which Ghana has a comparative advantage.

Key words: Trade, Productivity, South-South trade, Ghana, Manufacturing

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1. Introduction

Against the sluggish recovery of the world economy in recent years, newly emerging economies have been acknowledged as the major force pushing forward the world's economic development. In particular, the deepened Africa-China trade engagement has attracted much attention. By the end of 2010, China concluded bilateral investment treaties with 31 African countries (Ofodile, 2013). Two years later, China became the largest trade partner for Africa while Africa emerged as an important import source and one of the major investment destinations for China (Wang and Bio-Tchane, 2008; Ademola et al., 2009). China's rapidly growing presence has also proliferated across West African countries. In 2012, the Chinese goods imported by West Africa reached USD 18.1 billion while export from this region to China was worth USD 4.3 billion (Agyekum et al., 2015). Following this trend, increasing studies (Kaplinsky and Morris, 2009; Osabutey and Jackson, 2019) started moving their focus on the effect of South-South trade on knowledge spillovers and productivity gains. There are, nevertheless, few studies on the firm-level impact of bilateral trade, especially evidence comparing the impact of the trade links between Africa-South and Africa-North is scarce (Elu et al., 2010; He, 2013).

Ghana's economy has exhibited high levels of GDP growth over the past decades, achieving an average of 5.78% growth rate between 1995 and 2018 [1]. The share of Ghanaian industrial output in GDP has expanded to 33.97%, almost twice the ratio in 1992. Yet, evidence shows that this growth has mainly be contributed by other sectors than manufacturing (Teal et al. 2006; Sandefur, 2010; Frazer, 2005; Davies and Kerr, 2018), which was expected to be a potential engine of Ghana's economic growth. The share of manufacturing's contribution to GDP was estimated to be 9.37 by the end of 1990s and stagnated until the financial crisis in 2008. After falling to the lowest level in the past two decades, 5.84% in 2012, the share of manufacturing in GDP quickly recovered to the pre-crisis level, accounting for 11.27% in 2018.

The development of the manufacturing sector has been the top priority of Ghana's economic transformation agenda. Based on the country's comparative advantage in natural resources and low-cost labour, the government's industrialization policy helped the country to establish a range of manufacturing industries during the 1990s, such as food processing, tobacco, textiles, garment, timber products, chemicals and pharmaceuticals. Nevertheless, the past two decades have seen a more aggressive expansion of services than manufacturing (Honorati and de Silva, 2016). Growth and employment in manufacturing firms did not evolve as desired by the government.

Despite trade liberalisation and adoption of a series of policy instruments to promote competitiveness, e.g. exchange rate reform, the performance of Ghanaian manufacturing firms was weak (Sutton and Kpentey, 2012). Using a 4-wave manufacturing firm-level panel, Frazer (2005) concluded that exporting firms in Ghana are not necessarily more productive comparing to non-exporters. Teal et al. (2006) revealed that manufacturing output in Ghana declined at the beginning of this century. A similar trend was pictured by the drop of manufacturing employment between 2003 and 2013, and the weak performance of Ghana's manufacturing sector persisted (Davies and Kerr, 2018). In general, evidence on the positive correlations between trade and productivity in the Ghanaian manufacturing sector is limited.

While it is evident that openness to trade has had significant impacts on the economic development of Africa (Lall and Pietrobelli, 2002; Lall and Narula, 2004; Edward and Jenkins, 2015), several studies also pointed out that China's experiences of industrial development may be more adaptable for Africa's economic development than Western models (Osabutey and Jackson, 2019). The technologies developed in labour-rich emerging economics could be more compatible to the context of other developing countries (Fu et al., 2011), e.g. Sub-Saharan African countries (SSA). A rich strand of literature has attempted to verify the importance of South-South trade and economic integration for economic development of Africa (Ma and Delios, 2010; Danquah, 2018). Yet, not much has been written about the conditions under which the productivity gains derived from trade engagement would occur among Ghanaian manufacturing firms.

Using a sample of manufacturing firms from Ghana, the main objective is to examine whether trade integration with China is more beneficial than trade integration with the OECD countries in terms of productivity improvement. First, we explore whether engaging in trade has brought about potential productivity gains of Ghanaian manufacturing firms. While there are studies that analyse the impact of trade on productivity in Africa at the sector level (e.g. Edwards and Jenkins, 2015; He, 2013; Kaplinsky and Morris, 2009; Amighini and Sanfilippo, 2014), firm-level studies remain scarce in the African context. Firm-level data allow us to minimize the possible bias and measurement errors while controlling for firm heterogeneities, which are in general ignored in sector-level analyses. Elu et al. (2010) is one of the few empirical studies in this area that is based on firm level data. However, they measure trade openness using an aggregate trade-GDP ratio at the country level, which would inevitably suffer from the potential industry heterogeneity bias. Second, the current research contributes to the literature of appropriate technology (Fransman, 1984) by comparing productivity gains derived from Ghana's trade with China and the OECD. Understanding why trading with countries at different levels of development could yield different impacts will help policymakers in the developing countries to design appropriate industrial and trade policies. Third, this study also estimates whether the impact of trade on productivity is contingent on industry heterogeneity. While the literature has distinguished differences in technology spillovers between high- and low-technology industries, little has been done to examine whether firms in industries where a country enjoys a comparative advantage could benefit more from higher level of trade (imports and exports) and openness, and how this varies with trading partners. In industries with comparative advantage, firms incline to generate greater productive efficiency and achieve breakthrough in international markets because of closer distance to the world productive frontier (Lin, 2012; Fu and Gong, 2011). On the contrary, firms from industries that are far away from the country's comparative advantage would find it difficult to benefit from knowledge embedded trade activities.

The empirical analyses use a unique dataset that consists of firm- and industry- level trade information from Ghana. The findings suggest that the productivity of Ghanaian manufacturing firms benefit from trade and openness, but the productivity effects induced by trade are contingent on trading partners and industry context. Importing Chinese products significantly enhances productivity in Ghanaian manufacturing firms, while no evidence of productivity improvement is found from OECD-Ghana trade. Moreover, the learning effects are found to be greater in industries in which the country enjoys a comparative advantage.

The rest of the paper is organised as follows. Section 2 reviews the literature on the South-South trade and the productivity effect of trade. Sector 3 lays out the model specification. Data are described in section 4, and section 5 discusses the empirical results. The last section summarises the findings.

2. Literature review

2.1 Country background

Trade flows increase the likelihood of learning and productivity growth (Grossman and Helpman, 1991; Dollar, 1992; Fu, 2005; Schiff and Wang, 2006). A high level of openness and integration in the global production chain allows firms in both developing and least developed countries to better access strategic assets, such as technology, skilled personnel and markets, which will eventually lead to higher productivity and economic growth (Grossman and Helpman, 1991). When exporting to the global market, firms are incentivised to upgrade their production capacity and improve competitiveness (Fu, 2005). Importing advanced technology embedding goods may also yield potential knowledge spillovers. Internalisation activities in general create an efficient channel for developing countries to acquire knowledge assets (Narula and Driffield, 2012). Moreover, through intensive interactions with foreign companies, advanced technologies or efficient managerial practices are expected to be absorbed by local actors.

Ghana has experienced a rapid trade expansion during the past decades. In 1995 Ghana exported a total of USD1.38 billion and imported USD1.79 billion, resulting in a negative trade balance of USD0.41 billion. The total trade volume increased more than ten-fold and reached USD35.4 billion by 2018. The difference between USD20.5 billion exports and USD14.9 billion imports has resulted in a trade surplus of USD5.64 billion. The composition of top five exporting products remained unchanged between 1995 and 2018, including precious metal, mineral, food, metals, and wood, whereas the top five imported products were led by machinery, vehicles, metals, chemical, and mineral.[2]

Regarding the top trading countries, there has been a big shift in positions between 1995 and 2018. In 1995 the top five export destinations for Ghanaian products were all OECD countries: The Netherlands (21 per cent, as the share of total Ghanaian exports), US (13.9 per cent), UK (9.06 per cent), Germany (4.99 per cent) and France (4.87 per cent). By 2018, India became the largest export destination for Ghana, sharing 25.3 per cent of the total Ghanaian exports, followed by Switzerland (16.2 per cent), China (11 per cent), UAE (5.73 per cent), and The Netherlands (5.58 per cent). There has also been a noticeable change in terms of the import origins, from Europe as the largest import origin in 1995 to China which shared nearly 30 per cent of Ghanaian total import in 2018. Figure 1 and Figure 2 depict the shares of Ghana's trade by OECD and China between 1995 and 2018. Evidently, OECD countries as a block has been the major trading partner for Ghana. In 1995, more than 70 per cent imports to Ghana were from OECD countries whereas above 80 per cent of Ghanaian exports went to OECD countries. Although OECD countries are still the largest trading partners of Ghana, both import and export shares shrank to below 40 per cent by 2018.

<*Insert Figure 1 and Figure 2*>

The forging of closer trade links between China and Ghana has become a topic of debate among researchers and policy analysts. In Ghana, imports of Chinese goods moved from 3.98 per cent share of total imports in 1995 to 29.26 per cent in 2018. The total volume of imports from China increased exponentially, more than sixty–fold from USD 0.07 billion to USD 4.4 billion. In 2005, China overtook the US as Ghana's second largest trading partner after Nigeria. The year after, China became the largest import origin for Ghana and the share of imported Chinese goods/services to the total Ghanaian imports peaked in 2015, at USD 5.31 billion. The bilateral trade between the two countries reached USD 6.48 billion the same year.

Turning to the type of goods Ghana trading with OECD and China, similar compositions are observed for the Ghanaian exports while different patterns are found for imports. Consumer products (precious metals, wood products, and foodstuff) and natural resources (mineral and metals) are among the most popular Ghanaian exports to both OECD and Chinese markets. [3] Machinery accounted for the biggest proportion of imported products from both OECD and China. As shown in Figure 3 and Figure 4, imports from China was minimal in 1995 and started growing after 2001. In 2014, the value of imported Chinese machinery reached more than USD 600 million, greater than the sum of total imported machinery from OECD countries. Transportation products, e.g. vehicles, is also among the top three imports from OECD and China. Another category that accounts for a relatively large share of total Chinese imports to Ghana is plastic and rubber products, whereas mineral products accounted for the third largest imports from OECD to Ghana.

<*Insert Figure 3 and Figure 4*>

2.2 Trade openness and productivity

In general, trade liberalization can affect firm-level productivity through three main channels. Firstly, trade openness allows the in-flow of imported products and exposes domestic producers to foreign competition. The imported capital equipment can directly be used for machinery upgrading and contribute to the productivity improvement in LDCs. Trade also increases the availability of intermediate inputs that eventually lead to increased productivity levels in local firms. With a greater variety of intermediate inputs, domestic producers can choose cheaper, production compatible and technology appropriate ones that facilitate efficiency improvement (Bernard et al., 2003; Feenstra et al., 2005; De Hoyos et al., 2013). In addition, incorporating intermediate inputs into local production is expected to help firms in developing countries learn the embedded intangible ideas (Keller, 2004). A strand of literature has focused on the association between the rise of inputs and the creation of new domestic varieties in developing countries (Goldberg et al., 2010; Feng et al., 2012; Bas and Strauss-Kahn, 2015; Fu, et al., 2014). Their findings suggest that expanding the set of available inputs will directly influence the productivity level through a quality upgrading effect due to the presence of more diversified imported inputs.

Secondly, with the presence of foreign competition, domestic producers have to seek ways (e.g. technological upgrading) to enhance productivity and cut down the average cost. Increasing competitive pressures would reduce the gap between actual productivity and the maximum productivity (Kokko, 1994; Fu, et al., 2020). Various empirical studies have concentrated on this channel and shown that firm-level productivity is positively associated with the level of exposure of the domestic market to foreign competitors (Pavcnik, 2002; Fernandes, 2007). Pavcnik (2002) found evidence of plant productivity improvements in Chilean firms due to the competition from abroad during the late 1970s and early 1980s. Using Colombian manufacturing plant-level data, Fernandes (2007) also verified that exposure to foreign competition generates productivity gains. After controlling for observed and unobserved plant characteristics and industry heterogeneity, a strong negative impact of nominal tariffs on plant productivity appeared. Melitz and Ottaviano (2008), find that increased foreign competition accelerates the exit of less productive firms and motivates the expansion of more productive ones. Nonetheless, most of these studies are carried out on the assumption of a well-developed market with effective market entry and exit mechanisms. When a well-developed market is not present and firms have to face soft budget constraints, exports and foreign competition may not result in an aggregate productivity growth at the industry level (Fu, 2005).

Foreign competition is a two-edged sword which may benefit as well as damage economic growth. The economic booming of China and other emerging economies (EEs) intensifies competition in global markets and imposes additional pressure on manufacturing industries in Africa. Without adequate strategic resources and capabilities, firms from least developed countries may suffer from crowding out effects and exit the market. Meanwhile, the rapid growth of EEs puts pressure on the demand for natural resources and exporting raw materials does not necessarily support the diversification of industries in LDCs. Evidence shows that the imports of Chinese projects to African countries had trivial negative impacts on local employment (Kaplinsky et al., 2007; Alvarez and Claro, 2009; Edwards and Jenkins, 2015) and sector productivity (Stevens and Kennan, 2006; World Bank, 2004).

Thirdly, learning-by-exporting (Arrow, 1962) is another channel to improve firms' productivity (Grossman and Helpman, 1991). Apart from market exploration skills, exporting requires firms to offer competitive products that meet the international quality standards. Their technological capabilities and production efficiencies are therefore likely to be upgraded when giving feedbacks and technical assistance to importers in international markets. Based on firm level data from Ghana and Tanzania, Fu (2020) find that trade including both imports and exports and engagement with foreign customers are the most important sources of innovation in these countries. Moreover, the high degree of competition in the global market increases the firms' incentive to innovate and become more productive. Empirical evidence shows that some developing countries have enjoyed productivity improvement through information and technology spillovers in export markets and economies of scale (van Biesebroeck, 2005; Fu, 2005; Alvarez and Claro, 2009; Amighini and Sanfilippo, 2014). However, exporting does not necessarily cause higher productivity growth because firms may self-select to be exporters because of their high-productivity and competitive nature (Wagner, 2007). In addition, learning from exporting may largely be affected by the heterogeneity of export markets (Greenaway and Kneller, 2004; Damijan et al., 2010).

According to the theory of appropriate technology (Schumacher, 1973; Fransman, 1984; Segal, 1992), technology does not have to be so complex that it can only be developed or learnt by experts. Transferring knowledge through trade needs to be "appropriate" and compatible with demands and limitations associated with the recipients. In Africa, a more appropriate technology is characterised as more labour-intensive, less skill-using and heavily relying on local materials and resources (Segal, 1992). Therefore, when measuring the productivity spillover induced by international trade, different country and industry contexts need to be taken into account.

Although exporting and importing may provide learning opportunities, the extent of knowledge that can be translated into local use would be a function of the levels of technology content a trading partner provides, and the technology gap between domestic and frontier firms (Kokko, 1994; Amighini and Sanfilippo, 2014). Compared to trading with advanced economies, the South-South trade potentially brings greater benefits given that the firms in developing countries are likely to provide more accessible goods and services to each other (Lipsey and Sjoholm, 2011). Effective technological spillovers may emerge due to the smaller 'technology gap' (Gelb, 2005). Thus, technologies produced in the South, such as from China naturally become easier to adapt for countries from the South (UNCTAD, 2012). On the contrary, the knowledge embedded in imported goods may be too advanced for local firms to unwrap and may not contribute much to local economic growth if the technology gap is too wide (Greenaway and Milner, 1990). Studies suggest that South-South trade, as opposed to North-South trade, accommodates dynamic and long-term growth potentials to developing countries (Amsden, 1986). He (2013) uses the COMTRADE panel data to assess the impacts of the imports from China, in comparison with those from the United States and France, on sub-Saharan African manufactured exports. His findings confirm that trade with China has in general stronger and significantly positive effects across all sectors. Especially when absorptive capacity of the importing country is constrained and a sizeable substitution effect of imported intermediate goods is present in the importing country, it is better to import from a Southern country with a superior technology than from a Northern country with a very advanced technology. Nonetheless, narrow technology gaps may imply less learning potentials. The low technology contents embedded in Chinese products may offer limited learning opportunities.

Previous literature has also emphasized that industry heterogeneity affects the likelihood and intensity of trade spillovers (Bernard et al., 2007). Factors that affect trade differ by industry (Wolf, 2007). In industries where a country is likely to have a comparative advantage, learning from trade is likely to be achieved especially when the technological distance with trading partners is small (Fu et al., 2011). In Ghana, industries with comparative advantage receive relatively more capital and production resources, as well as policy support. These industries - such as food processing, textile and wood production - are normally characterized as low skilled labour-intensive and less knowledge-intensive components (Wolf, 2007). It may also be true that manufacturers in general have already accumulated production experience and possess some degree of technical competence. Owing to the low technical requirements, it is relatively easy to transform foreign knowledge embedded in imports of intermediate inputs into local production. Edwards and Jenkins (2015) explain that labour-intensive manufacturing firms are more sensitive and react more responsively to rises in Chinese imports by improving productivity. Similarly, exporting firms who have gained competitiveness are expected to respond to the global competition more effectively.

3. Model specifications

3.1 Trade engagement and labour productivity

The central question here is the productivity impact of trade activities. We start from an augmented Cobb-Douglas production function with labour, capital stock and intermediate inputs as factors of production, where total factor productivity (TFP) is affected by firm-specific and sector-specific characteristics, among which the trade variables are the central variables of interest. The production function is given by equation (1) where all variables are in logarithms:

$$Q_{i,t} = \alpha' I_{i,t} + \beta' X_{l,t} + \gamma' W_{i,t} + \lambda' Z_{l,t} + \eta_i + \varepsilon_{i,t} \quad (1)$$

$$with \quad \varepsilon_{i,t} = \rho\varepsilon_{i,t-1} + \mu_{i,t} \quad \text{and } \mu_{i,t} \sim N(0, \sigma^2)$$

$$I_{i,t} = \left(L_{i,t}, K_{i,t-1}, M_{i,t}\right)'$$

$$X_{l,t} = (EXI_{l,t}^{china}, EXI_{l,t}^{oecd}, IMPI_{l,t}^{china}, IMPI_{l,t}^{oecd})'$$

$$W_{i,t} = \left(Size_{i,t}, EX_{i,t}^{a}, EX_{i,t}^{n}, IMP_{i,t}\right)'$$

$$Z_{l,t} = (FDI_{l,t}, HH_{l,t})'$$

The indices *i*, *t* and *l* represent respectively firms, time and industries, $Q_{i,t}$ is gross output, $I_{i,t}$ is the vector of inputs ($L_{i,t}$ for the number of employees, $K_{i,t-1}$ for the physical capital stock at the end of year *t-1* and, $M_{i,t}$ for total materials), X_{lt} is the vector of industry-level trade intensities (*EXI* for the export to value added ratio of the industry the firm belongs to and *IMPI* for the import penetration ratio in industry value added, the superscripts *china* and *oecd* denoting trade with China and the OECD, respectively), W_{it} is a vector of firm-level characteristics. These include *Size*, measured by the number of employees; *EX*, the firm-level export to sales ratio, distinguished by export destinations to African countries (EX^a) and to non-African countries (EX^n); and *IMP*, the percentage of imported material inputs). Z_{lt} captures industry characteristics, namely the percentage of foreign asset in the industry (*FDI*) and the Hirschman-Herfindahl index of industry concentration (*HH*). The error term has two components: η_i captures time-invariant unobserved individual effects, whereas $\varepsilon_{i,t}$ denotes productivity shocks that follow a Markov process, where $\mu_{i,t}$ is the unexpected productivity shock.

3.2 Estimation method

We make three transformations to the production function equation (1) before proceeding to the estimation. First, in order to estimate the degree of returns to scale, we normalize the output and the three factors of production by the number of employees. In the case of constant returns to scale, the number of employees would disappear as a separate variable. In the presence of increasing (decreasing) returns to scale, the coefficient of the number of employees is positive (negative). The expression $\beta' X_{l,t} + \gamma' W_{i,t} + \lambda' Z_{l,t}$ represents total factor productivity.

Second, we follow Blundell and Bond (1998) and Bond and Guceri (2016) by quasi-differencing the equation to eliminate $\varepsilon_{i,t}$:

$$Q_{i,t} = \rho Q_{i,t-1} + \alpha_1'(I_{i,t} - \rho I_{i,t-1}) + \beta_1'(X_{l,t} - \rho X_{l,t-1}) + \gamma_1'(W_{i,t} - \rho W_{i,t-1}) + \lambda_1' Z(_{l,t} - \rho Z_{l,t-1}) + (1-\rho)\eta_i + \mu_{i,t} \quad (2)$$

Third, for more generality we do not impose the common factor restrictions and write (2) as an ADL(1,1) specification:

$$Q_{i,t} = \rho Q_{i,t-1} + \alpha_1' I_{i,t} + \alpha_2' I_{i,t-1} + \beta_1' X_{l,t} + \beta_2' X_{l,t-1} + \gamma_1' W_{i,t} + \gamma_2' W_{i,t-1} + \lambda_1' Z_{l,t} + \lambda_2' Z_{l,t-1} + (1-\rho)\eta_i + \mu_{i,t} \quad (3)$$

Because of the presence of a lagged dependent variable with an individual effect and because of the endogeneity of the three factors of production that are likely to be correlated with the individual effect, we estimate equation (3) by the generalized method of moments (GMM) developed by Arellano and Bond (1991) and Blundell and Bond (1998). We shall combine the orthogonality conditions of the differenced error term in (3) with 2 lags of the exogenous variables and those of the lagged first differences of the exogenous variables with the level of the error term in (3). Indeed, in empirical practice, using only lagged inputs to instrument for changes in inputs often causes the coefficient of the endogenous variable to be biased downwards and lead to insignificant and unreasonably low estimates. Blundell and Bond (1998, 2000) suggest that the system GMM estimator using in addition lagged first differences of the variables as instruments in the level equations often yields more reasonable parameter estimates. Since some of the explanatory variables only vary at the industry level, the standard errors are clustered at the industry level as recommended by Moulton (1990).

A notable feature of Equation (3) is that it allows us to derive both short-run and long-run productivity effects from trade. The coefficients α_1', β_1', γ_1' and λ_1' capture the short-run responses of productivity to changes in industry-level trade, firm-level trade and industry characteristics, while the $\frac{(\alpha_1'+\alpha_2')}{1-\rho}$, $\frac{(\beta_1'+\beta_2')}{1-\rho}$, $\frac{(\gamma_1'+\gamma_2')}{1-\rho}$ and $\frac{(\lambda_1'+\lambda_2')}{1-\rho}$ characterize the corresponding long-run responses.

4. Data and variables

To estimate equation (3) we need data for the factors of production, firm characteristics, industry characteristics and industry-level trade.

4.1 Firm-level variables

The firm-level dataset that has been used to construct $Q_{i,t}$, $I_{i,t}$ and $W_{i,t}$ in equation (1) - (2) comprises the manufacturing firms operating in Ghana. The survey was conducted by the Centre for the Study of African Economies (CSAE) at the University of Oxford, in conjunction with the University of Ghana, Legon and the Ghana Statistical Office.[4] It covers 12 waves and was collected in seven rounds over the period 1991-2002. The sample was intended to be broadly representative of the size distribution of firms across the major sectors of Ghana's manufacturing industry (Rankin et al., 2006). These sectors include food processing, textiles and garments, wood products and furniture, metal products and machinery. The original sample has a size of 312 firms, nearly a quarter (85 firms) of which are present in all waves and the rest (227 firms) only appears in certain segments of the survey period. Considering the estimation methodology requirement, we keep firms that are present for at least three consecutive waves. After cleaning the missing values, we are left with an unbalanced panel consisting of 201 firms and 1236 observations during the period under survey.[5]

The CSAE data contains critical indicators that are needed to estimate labour productivity. The output of a firm is computed at the real value of the manufactured gross output at 1991 firm-specific output prices. Reflecting the production capability, physical capital is imputed as the replacement value of plant and machinery (deflated in 1991 prices). The total number of employees captures the size of the firms. Material is computed as the total costs of raw materials in 1991 prices. The output and inputs are all expressed in logarithms.

To better control for firm heterogeneity, an extra group of firm-level indicators from CSAE is also employed in the estimation of equation (3). Firms were asked to give the percentages of output exported within and outside Africa. Including the trade variables at the firm level, in particular the exports distinguished by destination, allows us to find out the effect of intra- and inter-regional trade on productivity growth. The Herfindahl index indicates the level of domestic concentration (the opposite of competition) and is calculated as the sum of squared shares of a firm output in the total industry output of all firms in the sample. A competitive industry environment would, on the one hand, encourage productive firms to become more competitive and, on the other hand, crowd out the less productive ones. Therefore, a mixed effect is expected between the Herfindahl index and productivity. In addition, the presence of foreign capital may create technology spillovers and thereby foster productivity growth. We construct the FDI indicator for each industry using the ratio of assets owned by foreign firms in total industry assets. Ghana and other SSA countries have in the past two decades realized the importance of FDI to growth and development (Barthel et al., 2011). FDI has effectively affected their technological capabilities and competitiveness (Dupasquier and Osakwe, 2006; Morrisey, 2012).

4.2 Industry-level trade indicators

The industry-level trade variables ($X_{l,t}$) are taken from Feenstra et al. (2005). They are aggregated from the bilateral commodity-level COMTRADE data.[6] For example, $IMPI_{l,t}^{oecd}$ measures the industry-level imports (as a ratio to total industry value added in year *t*) from OECD countries to Ghana. The industry-level trade panel is matched with the CSAE firm-level panel for the period 1991-2002 since we know the industry that firm *i* belongs to. Following Feenstra et al. (2005), we have taken the importers' reports as the primary source assuming that they are more accurate than those reported by the exporters. The exporters' volume is used only when the corresponding importers' volume is unavailable.

<Insert Table 1 here>

One difficulty here lies in the calculation of trade intensity at the industry-level. To do so, outputs for each industry are needed. Yet, only data for 2003 can be found.[7] With the UN Industrial Production Index (UNIPI) and the 2003 data, outputs for each industry across the reviewing period are computed.[8] Using the industry level trade/output ratio is expected to remove the potential bias due to ignoring the weights of each industry in the total manufacturing sectors.

The industry trade shares were obtained by aggregating the commodity trade to SITC Rev. 2 using COMTRADE data. We consider productivity as a dynamic process where imports and exports play a role. Exp_China, and Exp_OECD denote the industry export volumes from Ghana to China and the OECD economies respectively, while Imp_China and Imp_OECD are the corresponding industry imports. Differentiating the trade with China from that with OECD economies allows us to compare the productivity gains of forming trade activities with the South and with the North. Definitions and summary statistics of the variables in the dataset are given in table 1.

4.3. Industry-level panel

To extend the empirical analysis to more recent years, we have employed additional data from the World Bank (WB) Investment Survey - Ghana 2006 and 2012 – to construct an industry panel for the period 1991 -2012.[9] The World Bank surveys contain data on the capital stock, materials, the total number of employees, and the annual turnover. However, they do not distinguish the trade by destinations. For that we use the trade with the OECD and China from the COMTRADE database as before. We drop the trade variables with Africa. FDI and the Herfindahl index can be calculated at the industry level as before.

Given that the firms included in the WB survey are different from those in the CSAE survey, matching the two datasets and conducting a firm-level study is not feasible. An alternative option is to construct an industry level dataset in which the sample firms are aggregated according to the industry they belong to. Firms from CSAE and WB are grouped into eight industries based on the 2 digits standard industrial classification. The industry mean values are calculated for each variable in equation (3).[10] After merging the twelve waves (1991 -

2002) from CSAE data and two waves (2006 and 2012) from the WB data, the industry sample comprises an unbalanced panel with 100 observations across 14 waves. It must be mentioned that the industries are not evenly distributed across the two datasets: the chemical industry makes up only 7% of total output in the CSAE databased compared to 38% in the WB data, the food industry 17% vs. 53% and the metal industry 26% vs. 5%. As can be seen in table 1, the average size of the industries in terms of output, capital and labour is lower in the WB dataset than in the CSAE dataset probably because of the different industry composition in the two datasets.

5. Empirical results and discussions

5.1 The firm-level productivity effect of Sino-Ghana Trade and OECD-Ghana trade

The first three columns of Table 2 present the estimates of equation (3) based on OLS, fixed effects and GMM estimators on the full sample. Given the fact that GMM tackles the endogeneity of factor inputs and the lagged dependent variable, the main interpretation will be based on GMM.[11] The upper panel presents the short-run effects on labour productivity whereas the lower panel calculates the long-run effects. The coefficient of the lagged dependent variable is positive and significant, indicating a sizeable persistence in productivity: more than half of labour productivity can be explained from the past labour productivity. As we would expect, the coefficient of the lagged dependent variable falls in between the coefficients estimated from OLS and FE, the former being overestimated and the latter underestimated. Consistent with the previous studies (De Loecker, 2011; Bond and Guceri, 2016), materials have the highest output elasticity while physical capital also enhances labour productivity. In the long run, a 1 percentage increase in capital per worker increases labour productivity by 0.12 percent. The negative sign of the logarithm of labour suggests returns to scale in the short run, but constant returns to scale cannot be rejected in the long run. Firm-level exports to non-African countries have a positive effect on productivity in the short run, but neither imports nor exports have a significant impact on productivity of Ghanaian manufacturing firms in the long run. The presence of foreign assets is positively associated with firms' productivity performance at least in the long run. Increasing the share of foreign assets in an industry enlarges the technological and managerial knowledge pool and therefore provides learning potentials for local firms operating in the same industry (Fu, 2018). The presence of foreign competitors is also expected to stimulate competition, which improves the local productivity. On the other hand, results show that productivity is higher in more concentrated industries following the Schumpeter hypothesis (coefficient of the Hirschman-Herfindahl index).

Compared to the trade relationships with the OECD countries, the trading relations with China create greater potentials for Ghanaian firms to enhance their productivity performance. Although more variety of the imported materials allows the domestic producers to choose cheaper, production compatible and technology appropriate ones that boost productivity, the exporting country also matters due to the technology gap between trading partners (Kokko, 1994). The Chinese goods exported to Africa are generally of decent qualities and well-priced, and fulfil the consumption needs of the local market. The relatively smaller technology gap with China allows Ghanaian firms to gain a higher potential by acquiring technologies embedded in Chinese products (Lipsey and Sjöholm, 2011).

<Insert Table 2 here>

As a main driver in the endogenous growth theory, such technology upgrading process would eventually promote productivity growth. On the contrary, acquiring technology from developed countries becomes difficult due to the inevitable technology gap. The positive and significant estimators of Imp_China indicate that the imports from China have helped the Ghanaian firms to advance their productivity level. Such effect was absent in imports from the OECD, as shown by the insignificant estimate of Imp_OECD in the long-run effects of Model 3. The costly imports from advanced countries may reduce the competitiveness of Ghanaian firms (Wolf, 2007). This finding is consistent with the previous literature (Kaplinsky and Morris, 2009; He, 2013), suggesting that South-South trade can promote economic development, which is particularly true for African countries. Trade between countries at similar levels of development is relatively more diversified (in terms of the range of products and activities) and transforming these products into domestic production is easier compared to trade between countries with greater gaps in the level of development. Yet, exporting to China induces no significant productivity effect. Surprisingly, exporting to OECD countries may harm productivity in Ghanaian manufacturing firms as suggested by the negative sign of *Exp_OECD* in the long run. Such negative effects could perhaps be caused by the high production costs incurred for products exported to the OECD because of the high entry standards of OECD markets. These costs reduce competitiveness (Wolf, 2007) and consequently hamper productivity.

To address industry heterogeneity, the full sample is divided into two subgroups by taking into account whether the industry has or not a comparative advantage.[12] The GMM results are displayed in Model 4 and Model 5 in Table 2. The first group (Industry 1) includes 126 firms from five industries with comparative advantages in Ghana: Food, Furniture, Garment, Textile and Wood. The remaining 75 firms are included in a second group (Industry 2). As the result shows, no scale effect appears in both sets of industries. Productivity spillovers created by the presence of foreign firms are more likely to be captured by the firms grouped in industry 1. Technology and production resources are scarce in industry 2, and firms belonging to this group are less likely to take advantage of the presence of foreign competitors (Morrisey, 2012). That is indeed what is reflected by the insignificant *FDI* in Model 5. When resources and policy instruments are both in favour of promoting the development of industries with comparative advantage, acquiring technologies from foreign companies and upgrading traditional firms' productivity tend to be achievable. The positive effect of concentration (the *Hirschman-Herfindahl* index) on productivity holds for both industry groups. Part of productivity may be due to mark-up pricing related to monopolistic competition.

The impact of the industry level trade intensity exhibits different patterns across the two groups (Industry 1 and Industry 2). Clearly not only trading partners matter, industry heterogeneity also explains the divergences in productivity performances. Trading with China yields broad effects on productivity in the sense that positive gains are derived from both importing and exporting, but only in industries where Ghana has a comparative advantage (Model 4). Such finding is in line with the literature on comparative advantage, arguing that the learning effects from trade engagement are likely to be higher in industries where a country has a comparative advantage because of accumulated know-how, learning by doing, possibly related to the abundance of some resource endowments to begin with (Bernard et al., 2007). In industries with comparative advantage, translating into local production the foreign knowledge embedded in imports is more straightforward since the technical requirement is relatively low and firms in these industries normally have already established some technical competencies. Industries where Ghana has no comparative advantage benefit from imports from China but derive no gain from exporting to China. In any case, the trade integration with China yields stronger productivity effects in comparison to that with OECD economies. Similar to the findings from model 3, both industry groups show negative effect of exporting to the OECD.

To explain the differences in productivity induced by trading with OECD and China, it would be necessary to further investigate the import compositions. However, constrained by the industry information given by the CSAE data (2-digit SITC), we were unable to disaggregate the industry-level imports to match the firms in the sample. Nevertheless, we have attempted to gain some insights by ranking the top imported products from OECD/China across industries for our sample of CSAE manufacturing firms. As expected, the composition of imports from China to Ghana differed considerably from that of imports from the OECD to Ghana. It is worth noting that imports from China to industries of our sample firms are concentrated in machinery and intermediate inputs, such as netting, woven products, batteries and flat-rolled stainless steel, which could potentially contribute to productivity improvement of manufacturing, especially in sectors with comparative advantage. Imports from the OECD consisted of machinery for construction purposes and a variety of consumer products such as clothing, generator and electronic products, which may have limited impact on the productivity of domestic manufacturing firms. The negative signs observed with regards to trade with the OECD may be due, besides the already mentioned need to satisfy high quality entry standards in OECD countries, to the fact that the exports from Ghana to OECD countries are highly concentrated in resource-oriented products.

5.2 Industry panel analysis

Ghana's participation in the World Trade Organization (WTO) started on 1 January 1995 and the trade volume has expanded dynamically ever since. The total exports have reached USD 14 billion in 2012 while imports soared to USD 17 billion. According to the WTO report on the trade policies and practices of Ghana (WTO, 2014), trade liberalization has helped Ghana to achieve a higher economic growth, especially after 2001. Nonetheless, the firm level analysis in the previous section only covers the period 1991 – 2002 due to the limited data. To extend the empirical analysis to a more recent period, we have also conducted an industry analysis with the panel stretching from 1991 to 2012. As explained before, we could not merge the CSAE data with the World Bank data at the firm level, and therefore we switched to an industry level analysis.

Similar to the firm-level analysis, the impacts of trade activities on productivity at the industry level are estimated with OLS, FE and GMM. One issue with respect to the specification that should be mentioned here is that the contemporaneous capital per worker is used to replace its lag in the model because relatively large time gaps exist between the last two waves (2006 and 2013). The impact of productivity from older years (6 years in the case of 2006 to 2012) is expected to be less correlated with the current one.

<Insert Table 3 here>

Table 3 presents the estimated results. Following the same approach as in firm-level analysis, the interpretation will be based on the GMM results (Model 8).[13] The trade variables are now treated as endogenous for reasons of simultaneity. The positive and significant sign of lagged output per worker shows a persistency in labour productivity, as expected smaller than with firm data. The output elasticities of capital and materials are consistent with those obtained with firm data. Returns to scale, shown by the coefficient '*Number of Employees'*, show up at the industry level in the long run, denoting scale effects external to the firm but internal to the industry. Consistent with the firm level analysis, concentration (Herfindahl index) yields a significant and positive productivity effect in the short run, but seems to vanish in the long run. The presence of FDI does not seem to affect the labour productivity at the industry level. Turning to the industry level trade intensity, importing from China still yields a productivity improvement, as suggested by the significant and positive coefficient of

Imp_China. Similar to the results generated with firm level data, trading with OECD countries does not seem to directly help Ghanaian industries to foster productivity growth. Because of the possible heterogeneity of the WB and CSAE data (see Table 1), we have estimated the same specification as Model 8, which combines WB and CSAE data, on the CSAE sample only. It can be seen that the estimates are quite similar on the full dataset and on the subsample of CSAE data in Model 9.

Since it is not directly linked to the labour productivity, trade costs, such as tariff barriers or quotas regulations can serve as good candidates to instrument imports and exports (Frankel and Romer, 1999). To check the robustness of our findings, Model 10 incorporates import tariffs as additional instruments for trade variables in the GMM estimation.[14] The regression covers the sample from 1995 to 2002 because we could not find tariff data before 1995. The estimated coefficients are in general consistent with Model 8. The positive and significant impact of Imp_China in the long-run shows up again, reinforcing our conclusion that productivity spillovers generated from importing goods from China are effectively present in Ghana.

One may be sceptical about the estimated coefficients given the small sample size - less than 100 observations and the difference in output composition across the two merged datasets. Nevertheless, findings from the fourteen-wave panel seem to confirm our firm level results. Trade helps the manufacturing industry in Ghana to achieve productivity gains, depending on the partners and types of trade activity. Forming trade relations with the South, where technological distance is relatively small, tends to benefit manufacturing productivity more than trading with Northern economies.

6. Conclusions

This research attempts to investigate the impact of trade on the productivity performance of Ghanaian manufacturing firms. Despite the weak performance of the manufacturing sector in Ghana that has been recorded in several studies (Frazer, 2005; Teal et al. 2006; Davies and Kerr, 2018), our findings suggest that openness to trade has, to some extent, provided effective drivers for Ghanaian manufacturing firms to improve their productivity. By engaging in the global production chain, firms may get access to foreign advanced technologies (Fu, 2020). Imports have helped Ghanaian manufacturing firms to enhance productivity by directly applying the imported machinery and equipment to local production. It also allows firms in Ghana to benefit from technology embedded imported goods and services through knowledge spillovers and reverse engineering, as well as to receive technological assistance from suppliers and customers in the global supply chain.

Trading with Southern countries creates greater productivity spillovers to Ghanaian firms compared to trading with OECD countries. Consistent with the appropriate technology theory (Schumacher, 1973; Fransman, 1984), imports of technology-intensive goods from China is likely to generate stronger productivity spillovers and promotes greater technological upgrading in recipient firms because Chinese technology is more appropriate to the African firms given the similar factor endowments in both countries and relative closer technology gap between the two countries. Meanwhile, industry heterogeneity also matters. Although trade stimulates productivity improvement, such effect does not happen automatically. Knowledge embedded in machinery and intermediate inputs need to be “appropriate” and compatible with the development levels of the local economy and industries. Our empirical results suggest that the learning effects tend to be greater in the industries where the country has a comparative advantage.

Inevitably, technology distances exist among trading partners. From the policy perspective, effective trade schemes not only need to consider the potential knowledge pools and learning opportunities provided by the partner countries, but also take into account the industry context such as comparative advantages of a country and its production capability and structure. To enhance productivity through international trade, policymakers in developing countries shall prioritise innovation, skills enhancement and technological upgrading in its domestic industry. This does not only enhance its productivity and competitiveness directly, but also serves to close the technology gap between local industry and trading partner countries, and increase the absorptive capacity of its industries.

The estimates generated from the firm-level data are in general consistent with those from the industry level data. Importing from China affects productivity in Ghanaian manufacturing firms more than trade with the OECD economies. However, as there are only two additional waves were added to the industry analyses after 2002, caution shall be taken when we draw conclusions. Moreover, current research assumes that the share of value added of each industry in the total manufacturing sector remains unchanged during the survey period. Such assumption is rather unrealistic given Ghana's increasing integration into the world economy, especially after joining WTO in 1995. It would be worthwhile revisiting this topic when more recent and comprehensive datasets become available.

Notes

[1] Data source: World Bank Development Indicators. https://databank.worldbank.org/source/world-development-indicators.

[2] Data source: UN Comtrade Database. https://comtrade.un.org/data/

[3] The top exporting and importing products are measured by the mean of total trade values during 1995 -2018. We also compared the subsamples 1995-2002 and 2003-2018. Differences are minor regarding the top traded products. Data source: COMTRADE data: https://comtrade.un.org

[4] The data can be found at the CSAE website: www.csae.ox.ac.uk.

[5] There are 2019 observations from 312 firms included in the sample across the survey period. After cleaning, 201 firms are left. Specifically, 228 observations are dropped due to missing values for firm level variables in equation (1), and another 81 observations are removed because of their appearing in fewer than three consecutive years. The estimation of Table 2 includes 1236 observations because of lags. The composition of manufacturing industries between the original sample and our sample is quite similar, with food, furniture, garment and metal accounting for about 70 per cent of the firms sample. The industry composition table is available upon request.

[6] For the detailed commodity-level data construction, please see Feenstra et al. (2005). The data can be found from www.nber.org/data (International Trade Data, NBER-UN world trade data). Feenstra et al. (2005) have organized the data by the 4-digit Standard International Trade Classification, Revision 2. We have further aggregated the data to the SITC 3-digit level in order to match the firm-level data from the CSAE industry classification.

[7] The value added 2003 data at industry-level can be found in the UNIDO database. It is the only year that is available for Ghana. http://www.unido.org/en/resources/statistics/statistical-databases.html.

[8] For the detailed computation of industry outputs, see appendix A.

[9] The industry panel covers the period 1991-2002 from CSAE, plus 2006 and 2012 from World Bank Enterprise Survey. In total, the industry panel consists of 100 observations across 14 waves. Specifically, there are in total eight industries: Chemical, Food processing, Furniture, Garment, Machinery, Metal, Textile and Wood. The 'Chemical' industry was not included in the first four waves, from 1991 to 1994. More information about the WB data can be found at http://www.enterprisesurveys.org/.

[10] Aggregated sums of variables are not used because the blown-up factors cannot be found for the CSAE dataset. Without the blown-up factors, it is not possible to move up from the sample to the whole population. The aggregated sums would misrepresent the industry sums. The mean values in this case are more representative if the sampled firms are randomly chosen.

[11] The number of degrees of freedom 69 in the Hansen test of overidentification equals the total number of orthogonality conditions (95) minus the number of estimated parameters (26).

[12] The choice of industries with comparative advantage is based on whether the industry belongs to one of the traditional industries in Ghana considering that these industries normally receive relatively more policy support and possess adequate production resources. These industries contributed about 30 per cent to the GDP in 1999 and absorbed about 15 per cent of the nation's workforce in Ghana. According to the Ghanaian industrialization policy, the following industries are categorized as traditional industry and almost all of them began as state-owned enterprises: producing food products, beverages, tobacco, textiles, clothes, footwear, timber and wood products, chemicals and pharmaceuticals, and metals, including steel and steel products. We selected the top five (785 observations from a total of 1236 observations) on the list as industries with comparative advantage in the current study as they were also listed as primarily promoted industries in the industrialization policy in 1999. Therefore, more capital and resources were expected to flow into these industries during the reviewing period. Specifically, our list includes Food, Furniture, Garment, Textile and Wood industries. Source: http://www.nationsencyclopedia.com/economies/Africa/Ghana-INDUSTRY.html.

[13] Similar to the firm level GMM, the instruments are collapsed to avoid too many instruments (Roodman, 2009). The number 148 in the Hansen test of overidentification equals the total number of orthogonality conditions (168) minus the number of estimated parameters (20).

[14] The tariffs are computed as the weighted averages of tariffs at the HS 4-digit level weighted by their corresponding ratio of trade at the HS 2-digit level in the corresponding country/region. The HS 4-digit tariff schedule Ghanaian imports were provided by Ghana Revenue Authority and Science and Technology Policy

Research Institute (STEPRE), Council for Science and Industrial Research (CSIR), Accra Ghana. The imports tariffs imposed on Ghanaian products by China and OECD countries were obtained from the World Integrated Trade Solutions (WITS), the World Bank: https://wits.worldbank.org.

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Table 1. Definition of variables and summary statistics: means and standard deviations for firm-level panel, 1991-2002, and means for industry panel 1991-2002 for CSAE and 2006-2012 for WB

Variables	Definition	Mean	S.D.	CSAE	WB
For computing firm productivity					
Output	Real value of manufactured output (1991 firm-specific output prices), in logarithm	17.27	2.17	19.59	15.31
Capital	Imputed replacement value of plant and machinery (deflator 1991 Cedis, million), in logarithm	16.13	3.09	19.87	13.89
Material	Total cost of raw materials (1991 firm-specific output prices), in logarithm	16.43	2.16	19.27	14.50
No. of employees ($Size_{i,t}$)	Total number of employees, in logarithm	3.19	1.39	5.46	5.40
Firm level trade variables					
Expfirm_Africa ($EX_{i,t}^{a}$)	Percentage of output exported within Africa	0.02	0.09		
Expfirm_nonAfrica ($EX_{i,t}^{n}$)	Percentage of output exported outside Africa	0.06	0.21		
Impfirm ($IMP_{i,t}$)	Percentage of raw materials imported	0.24	0.36		
Industry level trade variables					
FDI ($FDI_{l,t}$)	Ratio of total assets owned by foreign firms in total industry assets, calculated with sample firms	0.41	0.29	0.40	0.09
Herfindahl ($HH_{l,t}$)	The sum of squared shares of firm output/industry output, calculated with sample firms	0.30	0.18	0.36	0.30
Exp_China ($EXI_{l,t}^{china}$)	Industry level exports volume from Ghana to China, as a ratio to industry value added	0.23	0.43		
Exp_OECD ($EXI_{l,t}^{oecd}$)	Industry level exports volume from Ghana to the OECD economies, as a ratio to industry value added	2.64	6.61		
Imp_China ($IMPI_{l,t}^{china}$)	Industry level imports volume from China to Ghana, as a ratio to industry value added	0.25	0.06		
Imp_OECD ($IMPI_{l,t}^{oecd}$)	Industry level exports volume from the OECD economies to Ghana, as a ratio to industry value added	8.83	11.16		

Note: CSAE is Centre for the Study of African Economies and WB is World Bank.

Table 2 Impact of trade on productivity: firm level panel, 1991 to 2002.

VARIABLES	Model 1 OLS	Model 2 FE	Model 3 GMM-SYS	Model 4 GMM-SYS Industry 1	Model 5 GMM-SYS Industry 2
			Short-run Effects		
Output/labour, lag	0.635***	0.290***	0.536***	0.451***	0.582***
	(0.043)	(0.029)	(0.081)	(0.080)	(0.147)
Material/labour	0.721***	0.710***	0.716***	0.711***	0.702***
	(0.023)	(0.027)	(0.017)	(0.026)	(0.017)
Capital/labour, lag (t-1)	0.038	0.014	0.066	0.114*	0.018
	(0.021)	(0.029)	(0.045)	(0.061)	(0.027)
Number of Employees	-0.191***	-0.188***	-0.295***	-0.246**	-0.252***
	(0.020)	(0.016)	(0.086)	(0.123)	(0.085)
Herfindahl	0.065	0.053	0.082	0.117	-0.211
	(0.067)	(0.106)	(0.069)	(0.147)	(0.178)
Exp_Africa	-0.050	-0.083	-0.023	-0.065	0.164*
	(0.083)	(0.085)	(0.098)	(0.092)	(0.086)
Exp_nonAfrica	0.277***	0.294***	0.288***	0.333***	-0.755
	(0.077)	(0.070)	(0.072)	(0.079)	(0.764)
Imp_Firm	0.028	0.024	0.021	-0.020	0.079
	(0.027)	(0.034)	(0.030)	(0.025)	(0.070)
FDI	-0.000	0.006	-0.016	-0.024	-0.143
	(0.081)	(0.076)	(0.098)	(0.126)	(0.299)
Imp_China	-0.145***	-0.091***	-0.130***	-0.027	-0.073
	(0.039)	(0.021)	(0.044)	(0.031)	(0.053)
Imp_OECD	-0.000	0.006	0.001	-0.191*	0.002
	(0.002)	(0.004)	(0.002)	(0.100)	(0.004)
Exp_China	0.271**	0.205	0.310***	0.740***	0.163***
	(0.093)	(0.169)	(0.104)	(0.110)	(0.056)
Exp_OECD	0.003	0.004	0.001	-0.010***	-0.000
	(0.002)	(0.007)	(0.002)	(0.004)	(0.005)
			Long-run Effects		
Material/labour	0.848***	0.742***	0.852***	0.828***	0.775***
	(0.026)	(0.029)	(0.048)	(0.040)	(0.028)
Capital/labour, lag (t-1)	0.080***	-0.032	0.131***	0.095***	0.138***
	(0.010)	(0.035)	(0.035)	(0.017)	(0.030)
Number of Employees	0.053***	-0.118**	-0.002	0.073	-0.060
	(0.014)	(0.049)	(0.072)	(0.077)	(0.073)
Herfindahl	0.633***	0.398***	0.597***	0.578***	0.712***
	(0.088)	(0.153)	(0.084)	(0.140)	(0.176)
Exp_Africa	-0.035	-0.100	0.029	-0.075	0.309
	(0.208)	(0.130)	(0.208)	(0.094)	(0.387)
Exp_nonAfrica	0.234	0.319	0.256	0.438	-0.955
	(0.295)	(0.385)	(0.314)	(0.323)	(2.116)
Imp_Firm	0.063	0.047	0.016	0.049	0.036
	(0.064)	(0.031)	(0.060)	(0.093)	(0.123)
FDI	0.216***	0.121	0.197**	0.449***	0.313
	(0.066)	(0.134)	(0.092)	(0.169)	(0.356)
Imp_China	0.158***	0.167***	0.114**	0.154***	0.114**
	(0.052)	(0.040)	(0.058)	(0.060)	(0.053)
Imp_OECD	-0.000	0.017*	0.004	0.171	0.000
	(0.004)	(0.010)	(0.004)	(0.127)	(0.014)
Exp_China	0.469	0.379	0.513	1.800***	0.067
	(0.533)	(0.446)	(0.520)	(0.545)	(0.176)

Exp_OECD	-0.010*	-0.005	-0.015**	-0.017***	-0.018*
	(0.006)	(0.021)	(0.007)	(0.006)	(0.010)
AR(1) test			-2.170	-1.783	-1.673
Pr > Z			0.030	0.074	0.094
AR(2) test			-1.619	-1.556	-1.448
Pr > Z			0.110	0.120	0.148
Hansen test of overid.			60.176	69.844	70.599
Pr > chi2(69)			0.839	0.550	0.683
R-squared	0.948	0.841			
Number of firms		201	201	126	75
Number of observations	1,236	1,236	1,236	785	451

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Unless specified, robust standard errors clustered at the industry level are in parentheses. Estimations are based on equation (3). In GMM-SYS, the instruments are lagged levels and first differences of the exogenous variables. The Hansen test of overidentifying restrictions does not reject the validity of the instruments (see also note 11). Industry 1 includes 785 observations across five industries where Ghana has a comparative advantage: Food, Furniture, Garment, Textile and Wood. The other 451 observations belong to Industry 2.

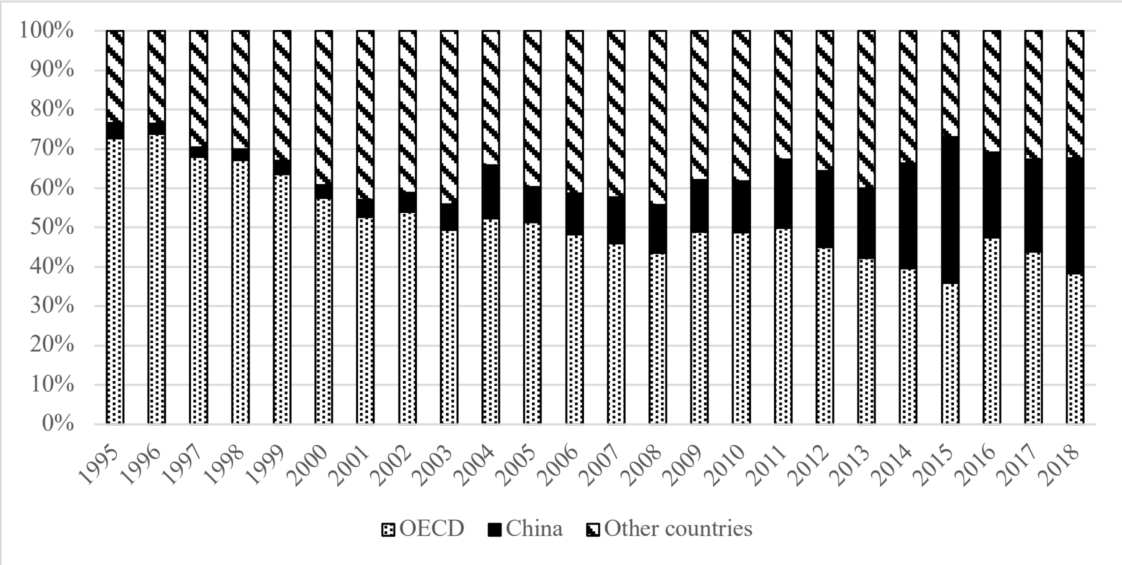
Table 3 Impact of trade on productivity: industry level

VARIABLES	Model 6 OLS	Model 7 FE	Model 8 GMM	Model 9 GMM	Model 10 GMM
	1991-2002, 2006 and 2012			1995-2002	
	Short-run Effects			Short-run Effects	
Output/labour, lag	0.202**	0.118	0.192*	0.229***	0.206**
	(0.080)	(0.115)	(0.108)	(0.082)	(0.101)
Material/labour	0.759***	0.774***	0.793***	0.713***	0.788***
	(0.060)	(0.070)	(0.050)	(0.071)	(0.044)
Capital/labour	0.087**	0.132**	0.098***	0.076**	0.085**
	(0.033)	(0.039)	(0.038)	(0.032)	(0.037)
Number of Employees	0.065	0.029	0.058	0.069	0.073*
	(0.054)	(0.057)	(0.044)	(0.058)	(0.042)
Herfindahl	0.380**	0.450**	0.369**	0.290***	0.406***
	(0.156)	(0.138)	(0.166)	(0.098)	(0.121)
FDI	0.142	0.000	0.235	0.219	0.131
	(0.109)	(0.178)	(0.148)	(0.193)	(0.183)
Imp_China	0.095	0.117	0.184	0.138	0.045
	(0.174)	(0.261)	(0.174)	(0.278)	(0.125)
Imp_OECD	-0.011	-0.010	-0.013	-0.000	-0.016**
	(0.012)	(0.013)	(0.011)	(0.022)	(0.007)
Exp_China	-0.477	-0.141	-0.515	-0.448	-0.719
	(0.846)	(0.640)	(0.704)	(1.085)	(0.473)
Exp_OECD	0.024*	0.018*	0.025***	0.027**	0.019**
	(0.010)	(0.008)	(0.008)	(0.011)	(0.009)
	Long-run Effects			Long-run Effects	
Material/labour	0.776***	0.823***	0.861***	0.780***	0.828***
	(0.121)	(0.156)	(0.119)	(0.132)	(0.094)
Capital/labour	0.110**	0.212***	0.148***	0.140***	0.108**
	(0.047)	(0.035)	(0.054)	(0.048)	(0.052)
Number of Employees	0.102**	-0.002	0.095***	0.101**	0.131***
	(0.047)	(0.086)	(0.035)	(0.049)	(0.033)
Herfindahl	0.335	0.485*	0.302	0.130	0.296
	(0.209)	(0.279)	(0.264)	(0.235)	(0.206)
FDI	0.053	-0.280	0.152	0.033	0.279
	(0.162)	(0.188)	(0.219)	(0.187)	(0.272)
Imp_China	0.339**	0.467***	0.558**	0.442**	0.376*
	(0.159)	(0.124)	(0.285)	(0.214)	(0.211)
Imp_OECD	-0.024	-0.021	-0.032	-0.018	-0.030
	(0.022)	(0.030)	(0.023)	(0.032)	(0.023)
Exp_China	-1.278	-0.278	-1.186	-0.006	-1.434
	(1.571)	(0.781)	(1.061)	(3.714)	(0.876)
Exp_OECD	0.012	0.002	0.007	0.003	0.014
	(0.023)	(0.029)	(0.015)	(0.033)	(0.013)
Instruments incl. tariffs			No	No	Yes
AR(1), z statistics			-2,532	-2.522	-2.510
p-value			0.011	0.011	0.012
AR(2), z statistics			-0.453	-0.601	0.074
p-value			0.651	0.548	0.941
Hansen test of overid.			58.813	47.696	55.199
p-value Chi2(148)			0.271	0.444	0.392
R-squared	0.920	0.899			

Number of industries		8	8	8	8
Number of observations	100	100	100	67	67

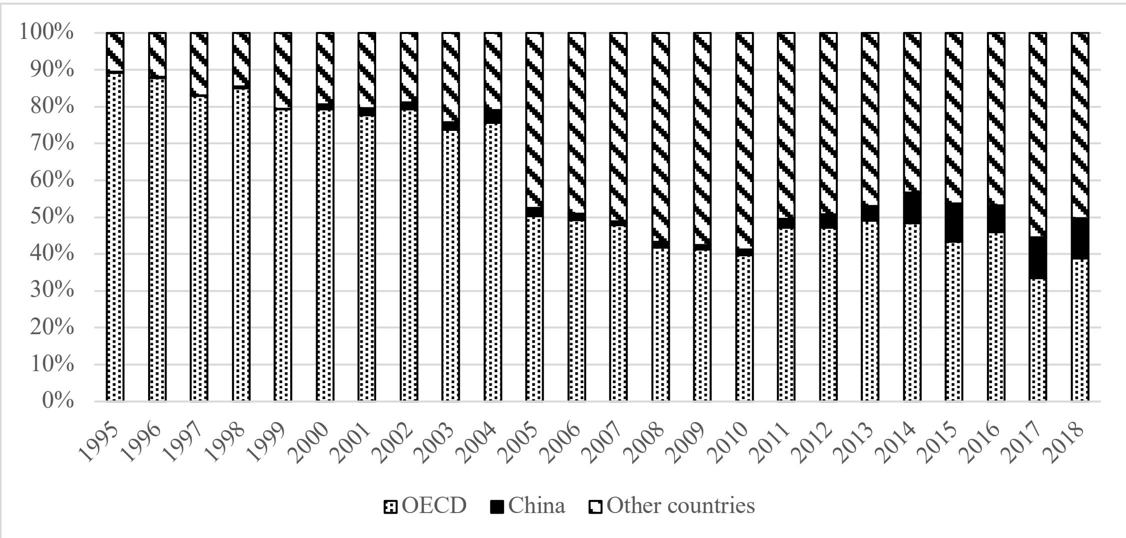
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Unless specified, robust standard errors are in parentheses. Estimations are based on equation (3). With respect to the system GMM, instruments are industry dummies, lagged levels and first differences of the exogenous variables. The Hansen test of overidentifying restrictions does not reject the validity of the instruments (see also note 13). Additional instruments for Model 10: average of HS 2-digit tariffs weighted by their corresponding trade value in the country/region.

Figure 1. Ghanaian imports origin composition: 1995 - 2018



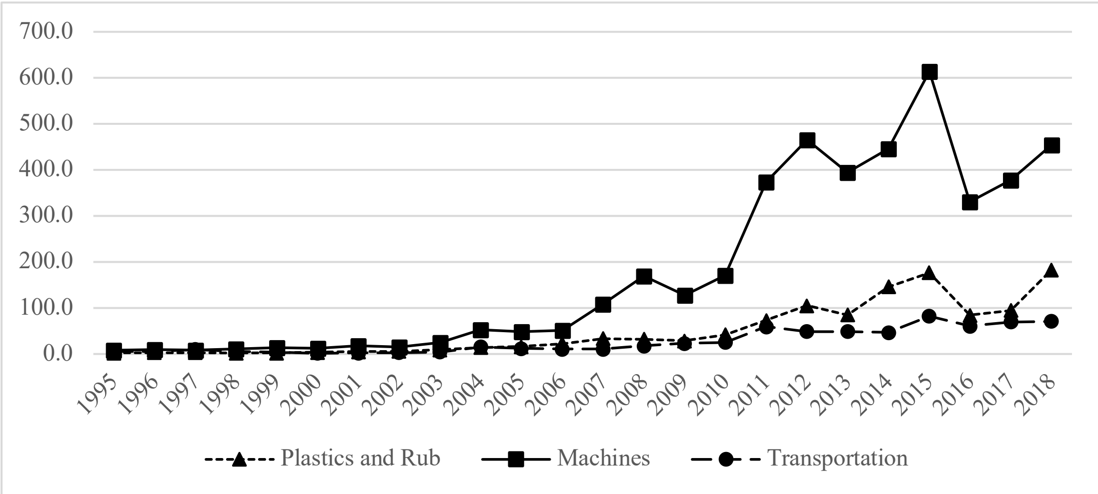
Source: COMTRADE Data: https://comtrade.un.org/data/

Figure 2. Ghanaian exports destination composition: 1995 -2018



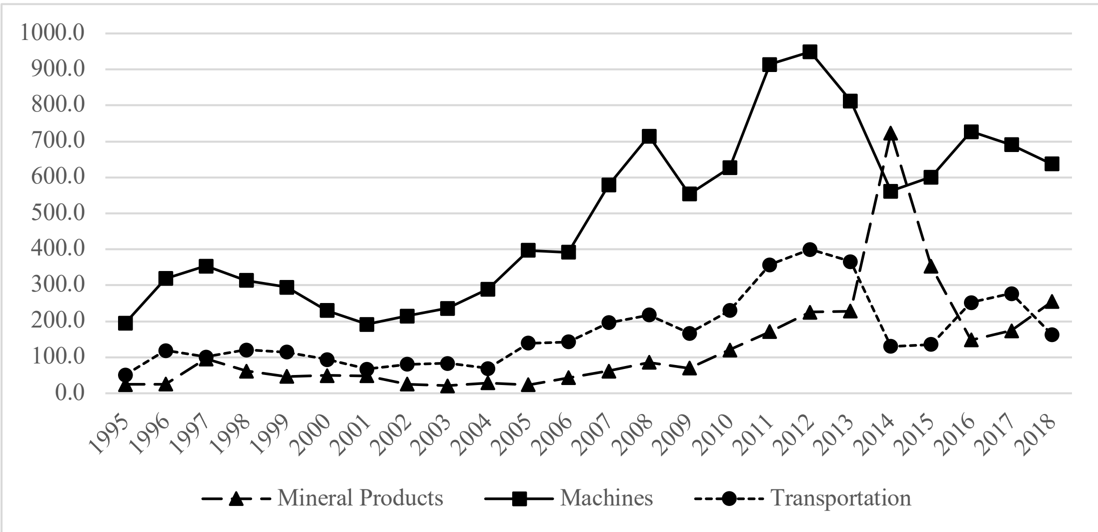
Source: COMTRADE Data: https://comtrade.un.org/data/

Figure 3. Top three imports from China to Ghana, in USD million



Source: COMTRADE Data: https://comtrade.un.org/data/

Figure 4. Top three imports from OECD to Ghana, USD million



Source: COMTRADE Data: https://comtrade.un.org/data/

Appendix A: Computing output value for each industry in the sample firms

This section explains how the outputs for each industry during the period under survey were constructed. To compute the trade intensity at the industry-level, which is the ratio of trade volume to industry output, we need the output value for each industry. However, only data for the year of 2003 were found in the UNIDO database (http://www.unido.org/en/resources/statistics/statistical-databases.html).We used the UN Industrial Production Index (IPI) obtained from the Ghana statistic service for 1990-2008 to calculate the outputs of each industry for other years.

Converting industrial production index (IPI) to industry output (1990-2008)

The UN Industrial Production Index is defined as the change in quantities (or volumes) of a specified basket of goods and services valued at the prices of the reference period 0, the computation of IPI is given as:

$$IPI_{i,t} = \frac{\sum_i p_{i,0} q_{i,t}}{\sum_i p_{i,0} q_{i,0}} = \frac{Output_{i,quantity\ t,price\ 0}}{Output_{i,quantity\ 0,price\ 0}}$$

where $p_{i,0}$ denotes prices of products for industry *i* at the base period 0. $q_{i,0}$ denotes quantity of products for industry *i* at the base period 0 whereas $q_{i,t}$ is quantity for industry *i* at period t.

The aim here is to calculate the aggregate output for industry *i* at price t. First, we convert the '$Output_{i,q=2003,\ p=2003}$' at the 2003 price into the base year 1997 price ($Output_{i,q=2003,\ p=1997}$); then the '$Output_{i,\ quantity\ 0,\ price\ 0}$' is computed based on the '$IPI_{i,2003}$ and '$Output_{i,\ quantity\ 2003,\ price\ 1997}$'.

$$Output_{i,q=1977,p=1997} = \frac{Output_{i,q=2003,p=1997}}{IPI_{I,t=2003}}\ .$$

Second, with '$IPI_{i,t}$'and '$Output_{i,\ q=1977,\ p=1997}$', '$Output_{i,\ q=t,\ p=1997}$' can be calculated as:

$$Output_{i,q=t,p=1997} = IPI_{i,t}\ \times\ Output_{i,q=1977,p=1997}.$$

Last, '$Output_{i,\ quantity\ t,\ price\ t}$' can be obtained by taking into account the inflation rates of each year and the currency will be converted to US dollar.

Industry outputs for sample industries (2008-2013)

However, the IPI were only available to the year of 2008. For the following years, we have adopted another method to compute the corresponding industry outputs. A gross value output of manufacturing for each industry was obtained from The Ghana Statistic Service. It was given in quarterly from 2006 to 2014 and only included data on sampled firms. This means not all the firms in the manufacturing sector were covered. With this information, we calculate the outputs for 2009-2013 by taking into account the growth ratios of industry outputs of sampled firms

$$Output_{i,t} = Output_{i,t-1} \times (1 + \frac{(Output_{sample\ i,t} - Output_{sample\ i,t-1})}{Output_{sample\ i,t-1}}).$$

'$Output_{i,\ t}$' denotes the outputs of industry *i* in year *t* ($t \geq 2009$) and '$Output_{sample\ i,\ t}$' denotes the outputs of industry *i* with sampled firms in year *t*. '$Output_{sample\ i,\ t}$' is proportional to '$Output_{i,\ t}$' and such computation requires that '$Output_{sample\ i,\ t}$' will well represent '$Output_{i,\ t}$'.