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

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Abstract: Using both firm-level and industry-regional panel analysis, this study investigates the impact of Ghana-China trade on total factor productivity (TFP) of Ghanaian manufacturing firms and compares that to the impact induced by Ghana-OECD trade. The main findings suggest that the TFP effect in Ghanaian manufacturing firms triggered by engaging in international trade activities is contingent upon industry heterogeneity and trading partners. The empirical results show that trading with China creates greater potentials for Ghanaian manufacturing firms to raise TFP in comparison to trading with OECD countries. The presence of higher intensities of Chinese imports stimulate TFP gains while exporting to China only enhances TPF among industries in which Ghana has a comparative advantage.

Key words: Trade, Total Factor Productivity, South-south trade, Ghana manufacturing firms, Productivity Spillover.

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 test whether trade integration with China is more beneficial than trade integration with the OECD 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 analysing the impact of trade and on productivity in Africa based on sector level analyses (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 allows 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 TPF 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 development countries to design appropriate industrial and trade policies. Third, this study also estimates whether the impact of trade on TFP 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). 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 TFP of Ghanaian manufacturing firms benefit from trade and openness, but the TFP effects induced by trade are contingent on trading partners and industry context. Importing Chinese products significantly enhances TFP in Ghanaian manufacturing firms, while no evidence of TFP improvement is found from OECD-Ghana trade. Besides, 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. 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. The presence of foreign competitors also forces firms from developing countries to improve their productivity and efficiency (Fu, 2012).

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 (COMTRADE, 2019).

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, 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. [2] Machinery accounted for the biggest proportion of imported products from both OECD and China. As shown in Figure 3 and Figure 4, import 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 (Habiyaremye, 2013). 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 and Iacovone, 2012). 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 (Martin and Page, 1983). 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) investigated the productivity impact of trade liberalization using Chilean plant-level panel data and found evidence of plant productivity improvements 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). Kaplinsky et al. (2007) illustrate that a high percentage of locally produced goods in countries like Ghana, South Africa and Ethiopia are experiencing a sharp drop or are forced to exit the market as a result of increasing imports from China. Such a displacement of local production by imported goods leads to significant job losses. At the plant level, Alvarez and Claro (2009) find that enhancing the market share of Chinese products negatively affects employment growth and the probability of survival of Chilean manufacturing plants. At the firm level, Elu et al. (2010) estimate a panel of the manufacturing firms of five sub-Saharan African countries between 1992 and 2004 and find no direct association between total factor productivity enhancement and trade openness with China.

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 advanced economies. During the course of market expansion, firms may also start exploiting economies of scale and increase their productivity (Fu and Balasubramanyam, 2003; Fu, 2005; Alvarez and Claro, 2009; Amighini and Sanfilippo, 2014) because relying on foreign markets enables firms to better avoid domestic demand shocks. Besides, the high degree of competition in the global market increases the firms' incentive to innovate and become more productive. Empirical evidence (van Biesebroeck, 2005) shows that some developing countries have enjoyed productivity improvement through information and technology spillovers in export markets. 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 TFP 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 (Melitz, 2003; 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 competiveness are expected to respond to the global competition more effectively.

3. Model specifications

3.1 Trade engagement and total factor productivity (TFP)

The central question here is to investigate the productivity impact of trade activities. Productivity is measured by TFP at the firm level. We follow the approach developed by Ackerberg et al (2015) to construct TFP.[3] Assuming the dynamic process of productivity is determined by the contemporaneous and lagged firm-level trade, industry-level trade and industry characteristics, we have an autoregressive distributed lagged, ADL (1, 1), specification:

$$TFP_{i,t} = \delta_1 TFP_{i,t-1} + \alpha_{p0} X_{l,t} + \alpha_{p1} X_{l,t-1} + \beta_{j0} W_{i,t} + \beta_{j1} W_{i,t-1} + \lambda_{k0} Z_{l,t} + \lambda_{k1} Z_{l,t-1} + \eta_i + \upsilon_t + \varepsilon_{i,t} \quad \text{with} \tag{1}$$

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

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

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

Where $TFP_{i,t}$ is total factor productivity of firm *i* at time *t*. *X*, *W*, *Z* are three sets of column vectors, consisting of both industry- and firm- level variables. Specifically, $X_{l,t}$ include the industry-level trade variables. $W_{i,t}$ contain firm-level characteristics whereas $Z_{l,t}$ capture industry characteristics respectively. *l* refers to the industry that firm *i* belongs to. α_{p0}, α_{p1}, $\beta_{j0}, \beta_{j1}, \lambda_{k0}, \lambda_{k1}$ are coefficients to be estimated, δ_1 captures the persistence of TFP. The industry characteristics are the percentage of foreign asset in the industry (*FDI*) and the degree of concentration (*HH*). The firm-level characteristics are *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 input material. The industry-level trade variables are *EXI* , the export to value added ratio of the industry the firm belongs to and *IMPI*, the import penetration ratio in industry value added, the superscripts *china* and *oecd* denoting exports to or from China and the OECD market, respectively, Industry dummies are included as control variables.

3.2 Estimation method

There are several econometric issues here. First, the knowledge contained in foreign assets and traded goods may take time to diffuse (Jaffe and Trajtenberg, 1998). Firms' adjustment to the intensity of competition in the industry also takes time. Both contemporaneous and lagged values therefore are used as explanatory variables. Second, there may be an omitted variables problem due to data unavailability. We use a dynamic model including the lagged dependent variable as one of the explanatory variables to reduce this problem because the lagged dependent variable is likely to capture the effects of many of the omitted variables. Third, bringing industry level data into firm level estimation may result in downward estimated standard error. Therefore, the standard errors are clustered at the industry level.

Subtracting $TFP_{i,t-1}$ on both side of equation (1), and adding and subtracting respectively $\alpha_{p0}X_{i,t-1}$, $\beta_{j0}W_{i,t-1}$, and $\lambda_{k0}Z_{i,t-1}$, we obtain the following Error Correction Model (ECM):

$$\Delta TFP_{i,t} = (\delta_1 - 1)[TFP_{i,t-1} - \frac{(\alpha_{p0} + \alpha_{p1})}{1 - \delta_1} X_{l,t-1} - \frac{(\beta_{p0} + \beta_{p1})}{1 - \delta_1} W_{i,t-1} - \frac{(\lambda_{p0} + \lambda_{p1})}{1 - \delta_1} Z_{l,t-1}]$$
$$+ \alpha_{p0}\Delta X_{l,t} + \beta_{j0}\Delta W_{i,t} + \lambda_{k0}\Delta Z_{l,t} + \eta_i + v_t + \varepsilon_{i,t} \quad (2)$$

where $\Delta TFP_{i,t}$, $\Delta X_{l,t}$, $\Delta W_{i,t}$, and $\Delta Z_{l,t}$, denote the first differences of *TFP*, *X*, *W*, and *Z*. Alternatively, equation (2) can also be written as

$$\Delta TFP_{i,t} = (\delta_1 - 1)TFP_{i,t-1} + (\alpha_{p0} + \alpha_{p1})X_{l,t-1} + (\beta_{p0} + \beta_{p1})W_{i,t-1} + (\lambda_{p0} + \lambda_{p1})Z_{l,t-1}$$
$$+\alpha_{p0}\Delta X_{l,t} + \beta_{j0}\Delta W_{i,t} + \lambda_{k0}\Delta Z_{l,t} + \eta_i + \upsilon_t + \varepsilon_{i,t} \quad (3)$$

A notable feature of the ECM is that it allows us to derive both short-run and long-run TFP effects from trade. In equation (2) the coefficients α_{p0}, β_{p0}, and λ_{p0} capture the short-run responses of TFP to changes in industry-level trade, firm-level trade and industry characteristics, while the $\frac{(\alpha_{p0}+\alpha_{p1})}{1-\delta_1}$, $\frac{(\beta_{p0}+\beta_{p1})}{1-\delta_1}$, and $\frac{(\lambda_{p0}+\lambda_{p1})}{1-\delta_1}$ characterize the corresponding long-run responses. The parameter $(\delta_1 - 1)$, or error correction coefficient of the ECM, is expected to be negative and takes a value in the range of zero and one. This parameter measures the deviation in the gap existing between the lagged TFP and its desired long-run equilibrium level given the contemporaneous *X*, *W*, and *Z* (Mulkay and Mairesse, 2013). The further it deviates from one (the closer to zero, in absolute value), the slower the adjustment of TFP to its equilibrium level.

Because of the potential endogeneity of trade and the omitted variables due to unobserved firm-specific effects, equation (3) is unlikely produce consistent estimates using the ordinary least squares method. It is reasonable to assume that firms with higher productivity levels have a strong competitive advantage, which allows them to engage in international trade. Similarly, industry-level import and export volumes are not independently chosen, but rather determined by the characteristics of the industry, including the efficiency of firms in the industry. This endogeneity problem, or simultaneity bias, is due to the correlation between the levels of trade and unobserved productivity shocks (De Loecker, 2007). To control for this problem, the empirical estimation of the current study will mainly rely on the generalized method of moments (GMM), in which lagged levels of the independent variables are chosen as instruments (Arellano and Bond, 1991). 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.

4. Data and variables

Equation (1) assumes that productivity is determined by the contemporaneous and lagged firm-level characteristics, industry-level trade and industry characteristics. To construct these three sets of determinants, we have obtained the industry (subscript l) and firm (subscript i) level information via various sources.

4.1 Firm-level variables

The firm-level dataset that has been used to construct $TFP_{i,t}$ and $W_{i,t}$ in equation (1) - (3) 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 1710 observations during the period under survey.[5]

The CSAE data contain critical indicators which are needed to estimate TFP. The output of a firm is computed at the real value of the manufactured gross output at 1991 firm-specific output prices. The output of a firm is a function of a series of inputs including physical capital, labour and raw materials. 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, used to proxy for unobserved productivity (Ackerberg et al., 2015), is computed as the total costs of raw materials at 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 (1). 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 TFP 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 TFP. 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 obtained from Feenstra et al. (2005), which is aggregated from bilateral commodity-level COMTRADE data.[6] For example, the $IMPI_{l,t}^{oecd}$ measures the industry-level imports (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 1991-2012 since the industry that firm *i* belongs to is given. In line with Feenstra et al. (2005), we have taken the importers' reports as the primary source assuming that these are more accurate than reports by the exporters. The exporters' volume is used only when the corresponding importers' volume is unavailable. Specifically, imports of Ghana record the volume from every country in the world. For the exports we use the trading partners' reported imports from Ghana rather than the Ghanaian reported exports whenever possible.

<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. Estimating the impact of trade activities on TFP performance (equation 1) considers TFP as a dynamic process in which the lagged TFP level and other lagged trade indicators are present. 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 and emerging economies 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. Extending to regional-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 a regional-industry panel for the period 1992 -2012.[9]

The WB data contain 616 firms in 2006 and 720 firms in 2012. The survey covers similar indicators as CSAE, including the capital stock, material input, the total number of employees, and the annual turnover. These indicators can be used to compute TFP following Ackerberg et al. (2015). Since the survey in 2012 did not distinguish the trade destinations, firm level trade variables are dropped from the regional-industry panel. Based on the number of foreign-owned firms and the total number of firms in each industry, FDI and the Herfindahl index can be calculated at the industry level. The estimation follows the same routine, in which first TFP is computed and then regressed on trade activities.

Given the fact 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 a regional-industry level dataset in which the sample firms are aggregated according to the industry and region they belong to. Specifically, firms from CSAE and WB are grouped into eleven industries based on the 2 digits SIC for every survey year, including 1992 – 2002, 2006, and 2012. Then each industry is broken down to four groups in line with one of the four regions the sample firms were located in. Each observation represents a specific industry in a specific region in Ghana. The regional-industry mean values will be calculated for each variable in equation (1).[10] It is worthwhile mentioning that the industries are not evenly distributed across the four Ghanaian regions. After merging the eleven waves (1992 - 2002) from CSAE data and two waves (2006 and 2012) from the WB data, the regional-industry sample comprises an unbalanced panel with 215 observations across 13 waves.

5. Empirical results and discussions

5.1 Obtaining firm-level TFP

Table 2 presents the results of estimating TFP by using different approaches for Ghanaian manufacturing firms during 1991 - 2002. All reported estimators are from the unbalanced panel estimation.[11] As indicated in the productivity literature (Olley and Pakes, 1996; Wooldridge, 1996 and 2009; Levinsohn and Petrin, 2003; Ackerberg et al., 2015), the OLS estimation (column 1 in Table 2) does not tackle the endogeneity of the various inputs, the fixed effects estimator (column 2 in Table 2) is expected to control for time invariant unobservables and the last column in table 2 displays the production function coefficients using the ACF semi-parametric estimator of Ackerberg-Caves and Frazer (2015).[12] The estimated output elasticities are not that different between the three estimation methods. The coefficient of the capital inputs from ACF is slightly higher compared to the other two approaches (Model 1 and 2 in Table 2). Among the three methods, the ACF is preferred and will be used for the TFP effect analyses because it partially corrects for the endogeneity of both labour and capital inputs.

<Insert Table 2 here>

<Insert Figure 5 here>

Figure 5 displays the ACF computed TFP (in logarithm) during the survey period. The TFP fluctuated but remained in the region between 0.78 and 0.84 before 1998. After three years of drop starting in 1995, it gradually recovered and increased until 2000. This trend is in general consistent with previous empirical evidence (Frazer, 2005; Davies and Kerr, 2017), which showed that the productivity of Ghanaian manufacturing firms fluctuated and in general performed poorly in 1900s and early 2000s. The shrinking of TFP during 1995-1997 was mainly led by the decline of output/value added (Rankin et al., 2002; Teal et al. 2006). Having estimated TFP, the next step is to examine the determinants of TFP, in particular the effect of the various sources of trade, following equation (1).

5.2 The productivity effect of Sino-Ghana Trade and OECD-Ghana trade

To understand how trade with China/EE differs from trade with OECD economies, we regress firm level TFP on (i) firms' past TFP performance to capture the dynamic nature of the process; (ii) firm's size; (iii) firm-level trade measures including the exports to African and non-African countries, as well as import intensities; (iv) industry-level indicators including FDI, competition and the industry-level trade measures. The estimation results are reported in Table 3.

The first three columns of Table 3 present the estimates based on OLS, fixed effects estimator and GMM on the full sample. Given the fact that GMM tackles the endogeneity issue, the main interpretation will be based on GMM.[13] The upper panel presents the short-run effects on TFP whereas the lower panel calculates the long-run effects. As expected, the error-correction coefficients $(1-\delta_1)$, which measure the equilibrium adjustment speed towards equilibrium, are negative and significant at the 1 percent level across all specifications. No scale effect is found in our sample of firms, as shown in all three specifications. Firm-level trade indicators do not show significant impacts on TFP of Ghanaian manufacturing firms. The presence of foreign assets is positively associated with firms' TFP performance. 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. Similarly, intensive competition within the same industry (1 - the Herfindhal index) forces the local firms to improve their productivity. But it could also be that productivity is higher in more concentrated industries following the Schumpeter hypothesis.

In general, results show that trade engagement with international players creates the channel for Ghanaian manufacturing firms to improve their TFP performance, but different patterns appear when trading with different partners. Compared to the trade relationships with the OECD countries, the trading relations with China create greater potentials for Ghanaian firms to enhance their TFP 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 importing 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 3 here>

As a main driver in the endogenous growth theory, such technology upgrading process would eventually promote TFP 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 TFP level. Such effect was absent in imports from the OECD, as shown by the insignificant estimate of L.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.

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.[14] The GMM results are displayed in Model 4 and Model 5 in Table 3. Group 1 (Ind.group1) includes 928 observations from five industries with comparative advantages in Ghana: Food, Furniture, Garment, Textile and Wood. The remaining 536 firms are included in group 2 (Ind.group2). As the result shows, the scale effect does not appear in both sets of industries. The coefficients of firm-level trade variables suggest that engaging in exporting outside of Africa stimulates productivity for Ghanaian manufacturing firms whereas exporting to African partners does not seem to improve productivity. This finding suggests that high levels of competitive pressures in the exporting market stimulate the productivity of exporters (Damijan et al., 2010; Wagner 2007; Greenaway and Kneller, 2004). Yet, such effect is only observed across manufacturing firms from group 1. Firms belonging to group 1 to some extent have accumulated experience and developed some learning capabilities. Similarly, TFP spillovers created by the presence of foreign firms are more likely to be captured by group 1 industries. Technology and production resources are scarce in group 2 industries, and firms belonging to this group are less likely to take advantage of the presence of foreign competitors (Morrisey, 2012), something that is reflected by the insignificant *FDI* in Model 5. In contrast, 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' TFP tend to be achievable. The positive effect of concentration (the *Herfindahl* index) on TFP holds only in group 2 industries. Part of TFP 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. Clearly not only trading partners matter, industry heterogeneity also explains the divergences in TFP performances. Trading with China yields broad effects on TFP in the sense that positive gains are derived from both importing and exporting (Model 4), but only in industries with comparative advantage. 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. The results of model 4 show that the two coefficients of trade with China are positive and significant at the 1 percent level. The trade integration with China yields stronger productivity effects in comparison to that with OECD economies, where Imp_OECD is not significantly different from zero.

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 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.

5.3 Regional-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 – 2003 due to the limited data. To extend the empirical analysis to a more recent period, we have also conducted a regional-industry analysis with the panel stretching from 1992 to 2012.[15]

The descriptive statistics of TFP (in logarithm), industry level trade variables and FDI are given in Figure 6. Ghana's trade volume with OECD countries as a ratio in regional-industry outputs is much higher than that with China. A clear expansion of trade is observed after 2002, reflected by the hikes of trade with both China and OECD. Since Ghana became a member of WTO in

1995, trading with China has increased rapidly until 2006 then experienced a drop in 2012. The trade between Ghana and OECD countries also rose but more persistently throughout the survey period and expanded nearly six and half times by 2012, compared to the same index in 1995. The trend of regional-industry logarithmic TFP is in general consistent with the firm-level TFP. A clear drop was observed since 1994 and then it entered a fast growth period from 1997 to 2002. Yet, there has been an evident decline in the extended period from 2002 onwards.

<Insert Figure 6 here>

Similar to the firm-level analysis, the impacts of trade activities on TFP at the regional-industry level are estimated with OLS, FE and GMM. One issue with respect to the specification that should be mentioned here is that the lagged TFP is not included in the model because relatively large time gaps exist between the last two waves (2006 and 2013). The impact of TFP from older years (6 years in the case of 2006 to 2012) is expected to be less correlated with the current one.

<Insert Table 4 here>

Table 4 presents the estimated results.[16] Following the same approach as in firm-level analysis, the interpretation will be based on the GMM results.[17] Measuring the speed to converge to long-term equilibrium, the error correction coefficients are all negative and significant. As to the magnitude (-0.489), it is also highly consistent with the adjustment speed reported in the firm-level results (-0.493). Returns to scale, shown by the coefficient '*No. of Employees'*, show up at the industry level, denoting scale effects external to the firm but internal to the industry. Consistent with the firm level analysis, concentration (Herfindahl index) and the presence of FDI yield significant and positive productivity effects. Turning to the industry level trade intensity, trading with China yields productivity improvement, suggested by the significant and positive coefficient *Trade_China*.[18] 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.

One may be sceptical about the estimated coefficients given the small sample size - less than 250 observations. Nevertheless, findings from the thirteen-wave panel seem to confirm our firm level results. Trade helps the manufacturing industry in Ghana to achieve TFP 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 TFP more than trading with Northern economies.

6. Conclusions

This research attempts to investigate the impact of trade on the TFP 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, 2017), our findings suggest that openness to trade has, to some extent, provided effective channels for Ghanaian manufacturing firms to improve their productivity. By engaging in the global production chain, firms may get access to foreign advanced technologies (Fu, 2012). Imports have helped Ghanaian manufacturing firms to enhance TFP by directly applying the imported machinery and equipment to local production. It also allows firms in Ghana to study technology embedded goods and services, as well as to receive technological assistance from actors in the global supply chain.

Trading with Southern countries creates greater TFP spillovers to Ghanaian firms compared to trading with advanced OECD countries. Consistent with the appropriate technology theory (Schumacher, 1973; Fransman, 1984), importing technology-embedding goods from China is likely to induce stronger TFP spillovers and allows recipient firms to upgrade their technological capability given the relative closer technology gap. Meanwhile, industry heterogeneity also matters. Although trade stimulates TFP 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. The empirical results reveal that the learning effects tend to be greater in the industries where the country has a comparative advantage and relatively more resources are allocated.

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 the production capability and comparative advantages. To enhance TFP through international trade, policymakers in developing countries are suggested to prioritise upgrading technological capability to close the technology gap between local industry and trading partner countries.

The estimates generated from the firm-level data are in general consistent with those from the regional-industry level data. Importing from China affects TFP in Ghanaian manufacturing firms more than trade with the OECD economies. But the results may be of limited relevance after 2002 given that only two additional waves were added to the regional-industry analyses. Another limitation of the current research is to assume 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 integration to the global value chain and the reallocation of domestic production resources, 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] The top exporting and importing products are measured by the mean of total trade values during 1995 -2018. We also compared the subsamples between 1995-2002 and 2003-2018, differences are minor regarding the top traded products. Data source: COMTRADE data: https://comtrade.un.org

[3] The TFP computation is calculated using STATA package '*prodest*'.

[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 3 includes 1464 observations because of lags, which reduce 246 observations from estimation of Table 2. The compositions of manufacturing industries between the original sample and our sample are highly similar, in which food, furniture, garment and metal account for about 70 per cent of sample firms. 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 regional-industry panel covers the period 1992-2012 from CSAE, plus 2006 and 2012 from World Bank Enterprise Survey. In total, the regional-industry panel consists 215 observations across 13 waves. 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 regional-industry sums. The mean values in this case are more representative if the sampled firms are randomly chosen.

[11] Estimators are generated by using STATA built-in commands *reg*, *xtreg* and *prodest* - STATA codes provided in Ackerberg et al. (2015).

[12] One limitation of the ACF method is the scalar unobservability assumption, i.e. the assumption that the unobserved heterogeneity in output is the only unobservable variable, there is for instance no unobservable in investment decisions, such as adjustment costs, or in pricing such as mark-ups.

[13] The number of orthogonality conditions in the GMM equals the number of instruments used for the endogenous variables plus the number of pre-determined variables (used as their own instruments). In total, 5 variables are considered to be endogenous (the differenced industrial level trade variables and the differenced firm level imports). The instruments are collapsed to avoid having too many instruments (Roodman, 2009). Thus, we consider the first differences in the error term to be orthogonal to the one-period lagged endogenous variables for each wave, from 1992 – 2002. That makes 50 orthogonality conditions. As to the level of the error term, we consider it to be orthogonal to the first differences in the endogenous variables. That makes 5 additional orthogonality conditions (collapsed). So, in total the system GMM (Model 3 in table 3) exploits 55 orthogonality conditions to instrument for the endogenous variables, plus 5 orthogonality conditions using the predetermined variables of our model (Number of employees, firm level exports to the African and Non-African countries, Herfindahl index and FDI) in the first difference equations, which makes a grand total of 60 orthogonality conditions. The number 39 in the Hansen test of overidentification equals the total number of orthogonality conditions (60) minus the number of estimated parameters (21).

[14] 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 (928 observations from a total of 1464 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.

[15] The regional-industry panel covers the period 1992-2012 from CSAE, plus 2006 and 2012 from World Bank Enterprise Survey. In total, the regional-industry panel consists 215 observations across 13 waves. More information about the WB data can be found at http://www.enterprisesurveys.org/.

[16] Years included in the 13 waves are 1992-2002, 2006 and 2012.

[17] The system GMM (in table 4) exploits 24 orthogonality conditions to instrument for the 2 endogenous variables (the differenced industrial level trade variables), plus 3 orthogonality conditions using the predetermined variables of our model (Number of employees, Herfindahl index and FDI) in the first difference equations, which makes a grand total of 27 orthogonality conditions. Similar to the firm level GMM, the instruments are collapsed to avoid too many instruments (Roodman, 2009). The number 16 in the Hansen test of overidentification equals the total number of orthogonality conditions (27) minus the number of estimated parameters (11).

[18] Due to the identification issues, the sum of imports and exports, *Trade_China* and *Trade_OECD*, are used in the regional-industry analysis.

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

[20] 1997 was chosen as base year because it was given as the reference year in the data obtained from Ghana Statistic Service.

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Table 1. Definition of variables and summary statistics: firm-level panel

Variables	Definition	Mean	S.D.	Min.	Max.
For computing firm TFP					
Output	Real value of manufactured output (1991 firm-specific output prices), in logarithm	17.27	2.17	11.49	25.49
Capital	Imputed replacement value of plant and machinery (deflator 1991 Cedis, million), in logarithm	16.13	3.09	9.54	23.64
Material	Total cost of raw materials (1991 firm-specific output prices), in logarithm	3.19	1.39	0.00	7.50
No. of employees	Total number of employees, in logarithm	16.43	2.16	8.92	24.49
Firm level trade variables					
Expfirm_Africa	Percentage of output exported within Africa	0.02	0.09	0.00	1.00
Expfirm_nonAfrica	Percentage of output exported outside Africa	0.06	0.21	0.00	1.00
Impfirm	Percentage of raw materials imported	0.24	0.36	0.00	1.00
Industry level trade variables					
FDI	Ratio of total assets owned by foreign firms in total industry assets, calculated with sample firms	0.41	0.29	0.00	0.91
Herfindahl	The sum of squared shares of firm output/industry output, calculated with sample firms	0.30	0.18	0.09	1.00
Exp_China	Industry level exports volume from Ghana to China, as ratio of industry value added	0.23	0.43	0.00	4.32
Exp_OECD	Industry level exports volume from Ghana to the OECD economies, as ratio of industry value added	2.64	6.61	0.00	49.17
Imp_China	Industry level imports volume from China to Ghana, as ratio of industry value added	0.25	0.06	0.00	0.44
Imp_OECD	Industry level exports volume from the OECD economies to Ghana, as ratio of industry value added	8.83	11.16	0.00	57.18

Table 2. Comparison of estimated coefficients of TFP computation, 1991-2002

VARIABLES	OLS	FE	ACF
Capital, log	0.087***	0.058***	0.101***
	(0.006)	(0.021)	(0.011)
Number of employees, log	0.210***	0.171***	0.192***
	(0.013)	(0.021)	(0.007)
Material, log	0.778***	0.697***	0.780***
	(0.007)	(0.010)	(0.006)
Observations	1,710	1,710	1,710
R-squared	0.968		
Number of firms	201	201	201

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. OLS: ordinary least squares, FE: fixed effects, ACF: Ackerberg, Caves and Frazer (2015)

Table 3 Impact of trade on TFP: comparing Ghana-China with Ghana-OECD from 1991 to 2002.

VARIABLES	Model 1 OLS	Model 2 FE	Model 3 GMM	Model 4 Industry 1	Model 5 Industry 2
		Short-run Effects		Short-run Effects	
Number of Employees	-0.056***	-0.066***	-0.014	-0.046	-0.085*
	(0.010)	(0.011)	(0.046)	(0.042)	(0.051)
Herfindahl	0.042	0.055	0.054	0.029	0.031
	(0.045)	(0.039)	(0.071)	(0.088)	(0.079)
Exp_Africa	-0.036	-0.018	-0.087	0.332	-0.310
	(0.039)	(0.048)	(0.194)	(0.267)	(0.329)
Exp_nonAfrica	0.102	0.142***	0.766	-0.278	-3.361
	(0.062)	(0.047)	(0.871)	(0.528)	(3.040)
Imp_Firm	0.005	0.001	-0.027	-0.105	-0.074
	(0.015)	(0.014)	(0.041)	(0.099)	(0.072)
FDI	-0.063*	-0.056*	0.035	0.066	-0.026
	(0.035)	(0.032)	(0.066)	(0.049)	(0.204)
Imp_China	-0.062**	-0.026	0.014	0.069	-0.072
	(0.031)	(0.038)	(0.047)	(0.069)	(0.056)
Imp_OECD	-0.001	0.004	-0.002	-0.011	0.000
	(0.002)	(0.003)	(0.004)	(0.076)	(0.004)
Exp_China	0.081*	0.138*	0.045	0.257	0.157**
	(0.046)	(0.072)	(0.083)	(0.179)	(0.080)
Exp_OECD	0.001	0.000	0.003	-0.001	0.000
	(0.002)	(0.002)	(0.003)	(0.007)	(0.004)
		Long-run Effects		Long-run Effects	
Number of Employees	-0.017**	-0.050***	-0.006	-0.019	-0.066
	(0.007)	(0.015)	(0.020)	(0.020)	(0.089)
Herfindahl	0.285***	0.216***	0.236***	0.170	0.311*
	(0.046)	(0.045)	(0.076)	(0.136)	(0.188)
Exp_Africa	0.032	0.029	0.047	0.364	-0.049
	(0.064)	(0.079)	(0.745)	(0.307)	(0.441)
Exp_nonAfrica	0.112*	0.196**	0.145	0.362**	-8.782
	(0.062)	(0.080)	(0.093)	(0.177)	(12.127)
Imp_Firm	0.024	0.007	-0.034	-0.193	-0.199
	(0.024)	(0.021)	(0.096)	(0.226)	(0.152)
FDI	0.064**	0.118***	0.139**	0.297**	0.275
	(0.032)	(0.045)	(0.066)	(0.142)	(0.296)
Imp_China	0.046	0.077***	0.101**	0.128*	0.024
	(0.030)	(0.026)	(0.051)	(0.077)	(0.097)
Imp_OECD	-0.002	0.011	-0.004	0.110	0.001
	(0.003)	(0.008)	(0.006)	(0.142)	(0.012)
Exp_China	0.046	0.283**	0.005	0.720*	0.155
	(0.144)	(0.123)	(0.178)	(0.375)	(0.200)
Exp_OECD	-0.000	-0.004	-0.003	-0.002	-0.006
	(0.002)	(0.005)	(0.004)	(0.008)	(0.011)
Constant	0.302***	0.559***	0.428*	0.302**	0.326*
	(0.025)	(0.048)	(0.220)	(0.147)	(0.174)
Error Correction Coefficient	-0.423***	-0.704***	-0.619*	-0.537***	-0.340***
	(0.028)	(0.025)	(0.317)	(0.158)	(0.127)
AR (1), z statistics			-2.53***	-2.65***	-3.67***
p-value			(0.01)	(0.01)	(0.00)
AR (2), z statistics			-1.50	-1.82	-0.12
p-value			(0.13)	(0.07)	(0.91)
Hansen overid. test, Chi2(39)			40.82	38.40	39.60
p-value			0.39	0.50	0.31
Observations	1,464	1,464	1,236	928	536
R-squared	0.258	0.425			
Number of Firms		201	201	126	75

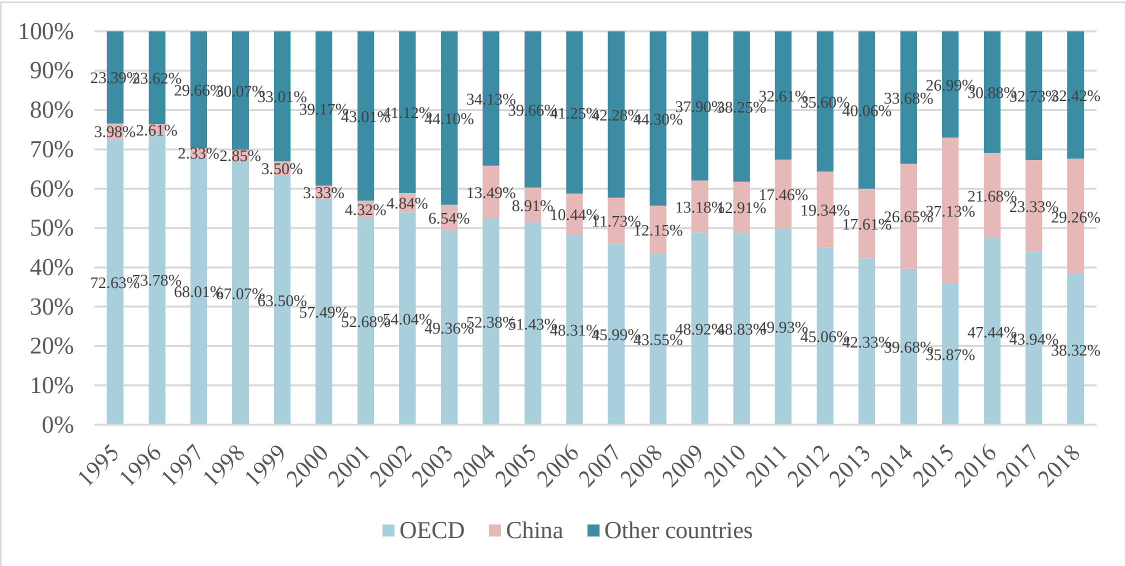
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Unless specified, robust standard errors are in parentheses. Estimations are based on the first-order ADL of equation (2). With respect to the system GMM, the instruments are industry dummies, lagged levels and first differences of the right-hand side variables. The Hansen test of overidentification does not reject the validity of the instruments (see also footnote 11). Ind.group1 includes 928 observations across five industries where Ghana has a comparative advantage: Food, Furniture, Garment, Textile and Wood. The rest of the sample firms (536) are included in Ind.group2. All independent variables are integrated of order 1, suggesting that first differences are all stationary. The lagged terms in the parentheses of equation (2) are also cointegrated (see Appendix B). As expected we cannot reject the presence of an autocorrelation of order 1 in the error term, but we can reject the presence of a second-order autocorrelation.

Table 4 The impact of trade on TFP: comparing Ghana-China with Ghana-OECD economies at the regional-industry level, 1992-2012

VARIABLES	OLS Model 6	FE Model 7	GMM Model 8
		Short-run Effects.	
Number of Employees	0.017	0.018	0.072***
	(0.014)	(0.012)	(0.028)
FDI	-0.003**	-0.002	-0.014
	(0.001)	(0.003)	(0.009)
Herfindahl	0.291**	0.341***	0.598***
	(0.136)	(0.078)	(0.128)
Trade_China	-0.003	0.006	0.027
	(0.017)	(0.014)	(0.023)
Trade_OECD	0.001*	0.001**	0.001
	(0.001)	(0.000)	(0.001)
		Long-run Effects	
No. of Employees	-0.027	-0.006	-0.001
	(0.018)	(0.019)	(0.030)
FDI	-0.020***	-0.009**	-0.022***
	(0.007)	(0.004)	(0.006)
Herfindahl	0.541***	0.572***	0.433***
	(0.144)	(0.114)	(0.122)
Trade_China	0.025	0.046**	0.068**
	(0.055)	(0.021)	(0.030)
Trade_OECD	-0.001	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Constant	0.254***	0.387***	0.387*
	(0.063)	(0.097)	(0.216)
Error Correction Coef.	-0.370***	-0.710***	-0.718***
	(0.073)	(0.081)	(0.248)
AR (1), z statistics			-2.23**
p-value			(0.03)
AR (2), z statistics			-1.37
p-value			(0.17)
Hansen overid. Chi2(16)			7.10
p-value			0.97
Observations	215	215	173
R-squared	0.281	0.391	
Number of ID	21	21	21

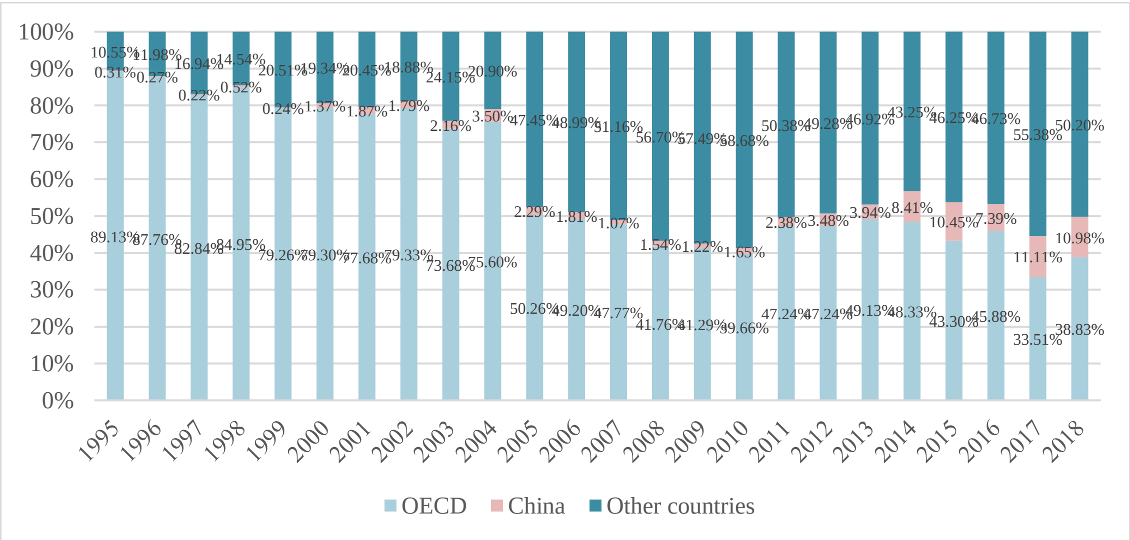
Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Unless specified, robust standard errors are in parentheses. Estimations are based on the first order ADL given equation (2). With respect to the system GMM, instruments are industry dummies, lagged levels and first differences of the right-hand side variables. The Hansen test of overidentification does not reject the validity of the instruments (see also footnote 16). 13-waves include year 1992-2002, 2006, and 2012. Model 8 applied GMM which dropped 64 observations because of lagged instruments. All independent variables are integrated of order 1, suggesting that first differences are all stationary. The lagged terms in the parentheses of equation (2) are also cointegrated (see Appendix B). As expected, we cannot reject the presence of an autocorrelation of order 1 in the error term, but we can reject the presence of a second-order autocorrelation.

Figure 1. Ghanaian imports origin composition: 1995 - 2018



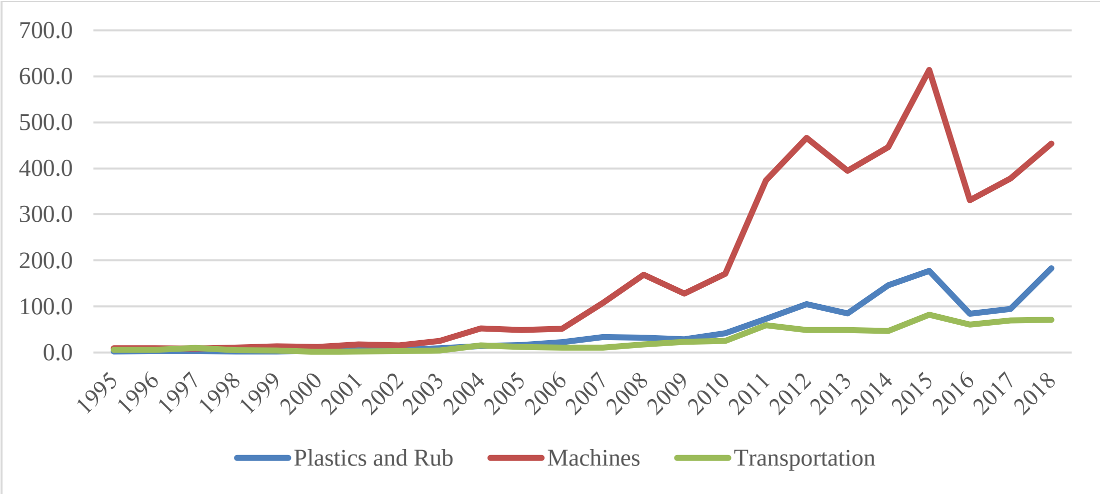
Source: COMTRADE Data: https://comtrade.un.org/data/

Figure 2. Ghanaian exports destination composition: 1995 -2018



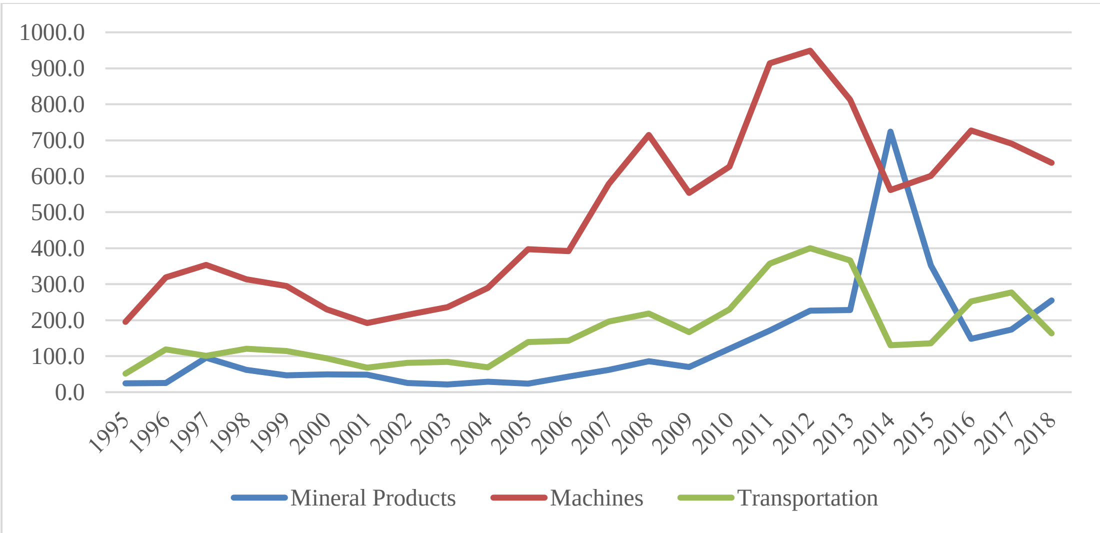
Source: COMTRADE Data: https://comtrade.un.org/data/

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/

Figure 5. ACF-based TFP levels from 1991 to 2002, in logarithm

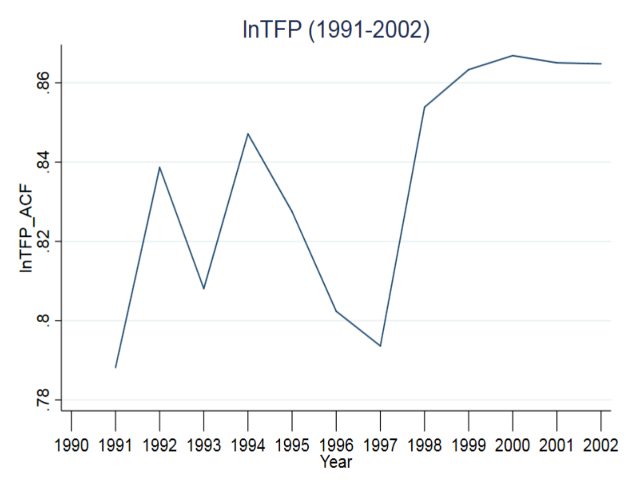
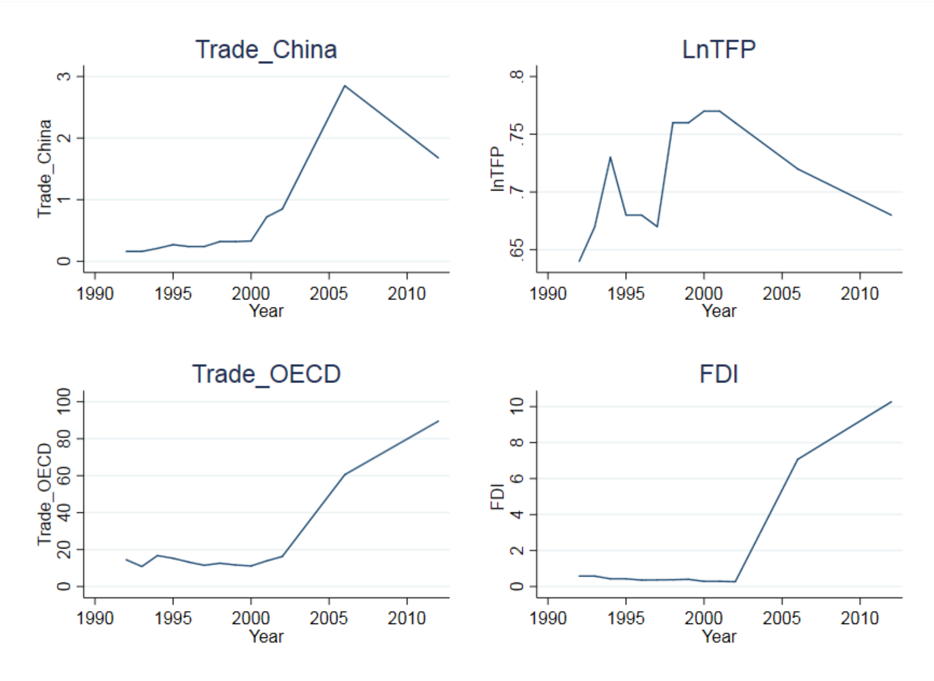


Figure 6. Summary of regional-industry variables



The computation of industry level trade variables with COMTRADE data follows the procedure explained in section 4.3. Trade_China and Trade_OECD are computed as the ratio of regional-industry outputs.

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. Computing the trade intensity at the industry-level, which is the ratio of trade volume to industry output, will need the output value for each industry. However, only data for the year of 2003 were found.[19] Given the limited data sources, we will use the UN Industrial Production Index (IPI) obtained from the Ghana statistic service to calculate the outputs of each industry for other years.

Comparing with using the aggregate industry outputs, adopting the ratio of trade volumes to outputs for each industry will efficiently remove the bias caused by ignoring the weights of each industry in the total manufacturing sectors. With the UN Industrial Production Index during 1990-2008 and the industry-level outputs in 2003, calculating the aggregated outputs for each industry becomes feasible.

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, 1977 price [20] ($Output_{i,q=2003,\ p=1977}$), then the '$Output_{i,\ quantity\ 0,\ price\ 0}$' will be computed based on the '$IPI_{i,2003}$ and '$Output_{i,\ quantity\ 2003,\ price\ 1977}$'.

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

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

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

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 '$Output_{i,t}$'.

Appendix B: Tests for unit roots and cointegration (Equation 2)

Harris-Tzavalis unit-root test.

H0: Panels contain unit roots; H1: Panels are stationary

VARIABLES	rho statistics	Z	p-value
D. No. of Employees	-0.2129	-28.3991	0.000
D. Herfindahl	-0.1648	-26.9819	0.000
D. Exp_Africa	-0.2823	-30.4473	0.000
D. Exp_nonAfrica	-0.3076	-31.1930	0.000
D. Imp_Firm	-0.1025	-25.1438	0.000
D. FDI	-0.1091	-25.3398	0.000
D. Imp_China	-0.1805	-27.4449	0.000
D. Imp_OECD	-0.6412	-41.0315	0.000
D. Exp_China	-0.3355	-32.0167	0.000
D. Exp_OECD	-0.6457	-41.1663	0.000
Number of panels	56		
Number of periods	11		

Note: Due to the fact that unit root tests on panel data require strongly balanced panels, the number of panels is reduced to 56.

Cointegration tests (bracket terms in Equation 2)

1) **Kao test for cointegration**: Dependent variable: lnTFP. Independent variables: No. of Employees, Herfindahl, Exp_Africa, Exp_nonAfrica, Imp_Firm, FDI, Imp_China, Imp_OECD, Exp_China and Exp_OECD.

2) **Pedroni test for cointegration and Westerlund test for cointegration**: Dependent variable: lnTFP. Independent variables: Imp_China, Imp_OECD, Exp_China and Exp_OECD.

H0: No cointegration H1: All panels are cointegrated

Tests	Test statistics	p-value
Kao test for cointegration		
Dickey-Fuller t	-4.6108	0.000
Augmented Dickey-Fuller t	-2.72	0.003
Unadjusted Dickey-Fuller t	-11.5366	0.000
Pedroni test for cointegration		
Modified Phillips-Perron t	8.3052	0.000
Phillips-Perron t	-3.7925	0.000
Augmented Dickey-Fuller t	-6.5566	0.000
Westerlund test for cointegration		
Variance ratio	3.6545	0.000
Number of panels	56	
Number of periods	11	

Note: Due to the fact that cointegration tests on panel data require strongly balanced panels, the number of panels is reduced to 56.