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Christian K. Darko, Giovanni Occhiali and Enrico Vanino

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By Christian K. Darko, University of Birmingham
Giovanni Occhiali, Fondazione Eni Enrico Mattei and Overseas Development Institute
Enrico Vanino, London School of Economics

Summary

This study uses firm level data on 19 Sub-Saharan Africa countries between 2004 and 2016 to provide a rigorous analysis on the impact of Chinese import competition on productivity, skills, and performance of firms. We measure import competition and ports accessibility at the city-industry level to identify the relevance of firms' location in determining the impact of Chinese imports competition. To address endogeneity concerns, a time-varying instrument for Chinese imports based on the interaction between an exogenous geographic characteristic and a shock in transportation technology is developed. The results show that imports competition has a positive impact on firm performance, mainly in terms of productivity catch-up and skills upgrading. Of particular interest is the finding that the effects of import competition from China are stronger for more remote firms that have lower port accessibility, an indication that Chinese imports in remote areas improves productivity of laggard firms, employment, and intensity of skilled workers. Our findings indicate that African firms are improving their performance as a consequence of the higher Chinese import intensity, mainly through direct competition and the use of higher quality inputs of production sourced from China.
Keywords: Import Competition, Productivity Catch-up, Trade Infrastructure, Skills, Employment, Sub-Saharan Africa, China

JEL Classification: F16, F61, F63, R11, J21, J24

Address for correspondence:
Enrico Vanino
London School of Economics
Houghton Street
London WC2A 2AE
United Kingdom
E-mail: e.vanino@lse.ac.uk

The Chinese are here: Firm level analysis of import competition and performance in Sub-Saharan Africa

Christian K. Darko[a], Giovanni Occhiali[b] and Enrico Vanino[c]

[a]*University of Birmingham*, c.k.darko@bham.ac.uk

[b]*Fondazione Eni Enrico Mattei & Overseas Development Institute*, gocchiali1987@gmail.com

[c] *Corresponding author: London School of Economics*, e.vanino@lse.ac.uk

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Abstract

This study uses firm level data on 19 Sub-Saharan Africa countries between 2004 and 2016 to provide a rigorous analysis on the impact of Chinese import competition on productivity, skills, and performance of firms., We measure import competition and ports accessibility at the city-industry level to identify the relevance of firms' location in determining the impact of Chinese imports competition. To address endogeneity concerns, a time-varying instrument for Chinese imports based on the interaction between an exogenous geographic characteristic and a shock in transportation technology is developed. The results show that imports competition has a positive impact on firm performance, mainly in terms of productivity catch-up and skills upgrading. Of particular interest is the finding that the effects of import competition from China are stronger for more remote firms that have lower port accessibility, an indication that Chinese imports in remote areas improves productivity of laggard firms, employment, and intensity of skilled workers. Our findings indicate that African firms are improving their performance as a consequence of the higher Chinese import intensity, mainly through direct competition and the use of higher quality inputs of production sourced from China.

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Keywords: import competition; productivity catch-up; trade infrastructure; skills; employment; Sub-Saharan Africa; China.

1. Introduction

The expansion of China-Africa trade relations has been one of the most remarkable in the developing world. In Africa alone imports of manufactured goods from China are more than 50 times larger since the accession of China to the WTO. As shown in Figure 1, while the share of imports from major partners such as the UK decreased from 13.9 % in 1990 to 2.3% in 2015, and from 13% in 1992 to 4.6% in 2015 for the US, China's share of total imports in Sub-Saharan Africa (SSA) rose to 16.5% from just 1.1% over the same period (WITS, 2017).

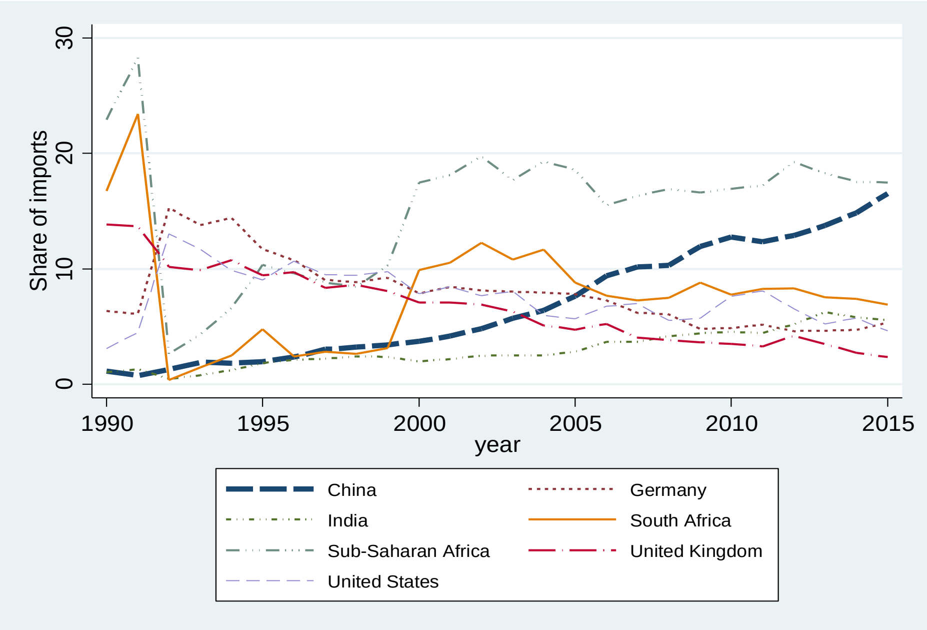


Figure 1. Import partner share

Elaboration based on data from WITS (2017)

Growing economic flows between China and SSA have been accompanied by changes in trade patterns. As shown in Figure 2, from the early 2000s there have been a move away from products such as footwear and light manufactured towards more sophisticated and higher-technology goods (WITS, 2017), making China the highest import partner for machines and electronics relative to the US and other European countries for the region.

The presence of China in Africa can be viewed as a great opportunity, mainly through possible knowledge exchange, and technology advancement through investment and exposure to new goods (Frankel and Romer, 1999; Arora and Vamvakidis, 2005), thus serving as a stimulus for economic development. On the other hand, it is also possible that the emergence of China on the continent may present detrimental effects, such as crowding out of domestic firms. These possibilities raise important questions on the impact China may have on the region.

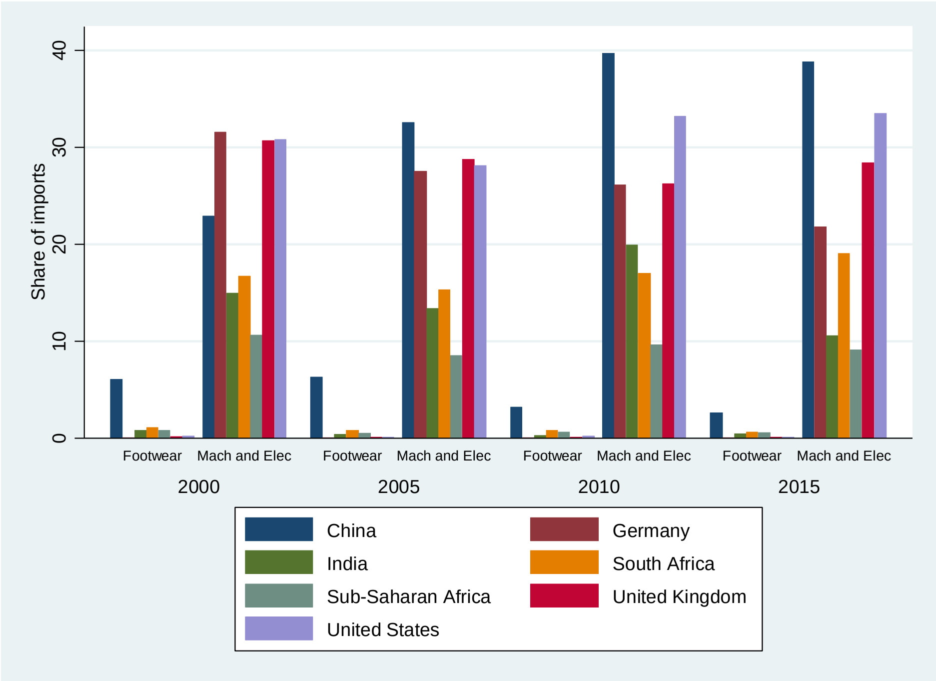


Figure 2. Import share in footwear and machine, and electronics, 2000 – 2015

Elaboration based on data from WITS (2017)

A growing body of literature has emerged over the last decade examining the economic implications of China's accession into the global economy. Most of these studies have focused on the impact in developed countries, and results are largely mixed. In the US, growth and manufacturing plant survival were found to be negatively related to exposure to imports from low-wage countries (Bernard et al., 2006), with negative implications for domestic employment (Harrison & McMillan, 2011; Donoso et al., 2015). Autor et al. (2013) have analysed the effects of rising Chinese import competition on US labour markets, finding that higher exposure to Chinese imports has decreased manufacturing employment and wages between 1990 and 2007. In Europe, Bloom et al. (2015) find Chinese import competition to increase firms' innovation, IT investment and creation of patents. They also find an increase in R&D and skills of domestic firms, in addition to increase in productivity, consistent with the pro-competitive effect of trade (Melitz, 2003). However, Mion and Zhu (2013) show that import competition from China, rather than from other low-wage and OECD countries, tend to reduce employment growth and skills in low-tech manufacturing industries. This is consistent with Rodrik (2006) and Schott (2008), who both find that Chinese exports show more similarities with exports from other OECD countries, and have different characteristics compared with exports from other low-wage countries. Álvarez et al. (2009), find adverse employment growth impacts on manufacturing firms in Chile, an effect they associate with the lack of adequate human capital which may limit the ability of firms to move toward more sophisticated products. Studies for Asia have also shown that Chinese exports tend to crowd out exports of other Asian countries, particularly in markets for consumer goods, but not so for capital goods' markets and imports from advanced economies (Eichengreen et al., 2004).

Studies that have analysed the implications of Chinese imports for Africa have been limited to South Africa, with results indicating adverse effects on exports (Edwards and Jenkins, 2014), and a negative impact on domestic production and employment (Edwards and Jenkins, 2015). Other descriptive evidences suggest beneficial trade relationships mainly through import of cheaper manufactures (Zafar, 2007), access to a wider variety of final and intermediate goods (Ademola et al., 2009) and benefits through technology-embodied imports (Maswana, 2009). Especially at the firm level, there is an evident gap in understanding the causal mechanisms of Chinese imports on firm performance in Africa, owing largely to the lack of comprehensive firm level data.

In this study, we use a rich panel dataset from the World Bank Enterprise Survey (WBES) for 19 Sub-Saharan Africa countries between 2004 and 2016 to address this knowledge gap. To the best of our knowledge, this study provides the first micro-level dynamic analyses of the impact of Chinese imports competition on the performance of SSA firms. Another significant contribution of this study is that we are able to distinguish the heterogenous effects of Chinese import competition on productivity and other measures of firm performance according to their access to ports. We thus, examine how port accessibility moderates this relationship. The poor infrastructure networks in the region has been found to limit firms' access to productivity-enhancing inputs and to foreign markets (World Bank, 2017; Aggarwal et al., 2017). To examine how Chinese imports affect firm performance, we construct a city-industry import variable using data from COMTRADE, and then weight the country-industry import variable with the share of each city in total employment within the industry and country over time. To identify the channels through which imports from China affects firm performance, we estimate an index of port accessibility for each city using a trade gravity model. We further address the endogeneity of import competition by developing a time-varying instrument that is based on an interaction between an exogenous geographic characteristic and a shock to transportation technology that affects trade partners differently. The geographic characteristic that we exploit is the presence of coastal features that allows for deep-water ports in Sub-Saharan Africa, while the technological shock is related to the quadrupling of the maximum size of container ships since the mid-1990s (ITF-OECD, 2015).

Our results show that import competition from China has positive impact on productivity, in line with the theoretical predictions that greater exposure to trade forces least productive firms to exit the market, triggering a within-industry market share reallocations towards more productive firms (Bernard et al., 2003; Eaton et al., 2007). We also find positive effect of import competition on skill intensity, which we associate to a shift in the production from low quality to more advanced goods. This finding is consistent with previous evidence showing that import competition facilitates skill-upgrading within firms (Crinò, 2012). In relation to the role of port accessibility, we find that Chinese imports have a stronger positive effect for more remotely located firms, an indication that Chinese imports might have penetrated areas that previously had less or no foreign competition. A placebo test using trade from the rest of the world (ROW) shows no significant impact on firm performance, confirming the peculiarity of the Chinese imports for the development of SSA firms.

This study relates to several strands of the literature. First, the literature on trade liberalization in the presence of heterogeneous firms, predicting aggregate productivity gains as a result of resource reallocation from the least to the most productive firms (Melitz, 2003; Dunne et al., 2008) and an heterogeneous effect of trade liberalization which will affect firms differently (Lileeva and Trefler, 2010; Bloom and Van Reenen, 2016). This literature has established that access to cheaper, better quality and a wider variety of intermediate inputs is associated with greater firm productivity (Topalova and Khandelwal, 2011; Bigsten et al., 2016), higher markups (Brandt et al., 2017) and product quality improvements (Amiti and Khandelwal, 2012). Secondly, the study relates to the literature on trade effects on labour markets. Most of the studies in this field find negative consequences of imports from developing countries on local labour markets (Bernard et al., 2006; Harrison & McMillan, 2011; Álvarez & Opazo, 2011; Freeman, 1995; Autor et al., 2013; Donoso et al., 2015). However, import competition from developing countries has been found to trigger a substantial variation in the composition of skills in manufacturing industries, shifting import-competing firms to the production of skill-intensive goods (Goldin and Katz, 1998; Acemoglu, 2002; Crinò, 2012; Lu and Ng, 2013; Acemoglu et al. 2015). Lastly, our work is related to the literature on the effect of road networks and infrastructure on economic activities and development (Banerjee et al., 2012; Gollin and Rogerson, 2014; Gibbons et al. 2016; Bernard et al. 2016; Asher and Novosad, 2016; Aggarwal, 2017). Several studies have shown that better transport infrastructure decreases the costs of interregional and international trade, thus, encouraging competition and facilitating firms' participation in international trade (Volpe Martincus and Blyde, 2013; Shiferaw et al., 2015; Cosar and Demir, 2016; Donaldson, 2018). In particular, some recent contributions have highlighted the role played by transportation costs in shaping the intra-national distribution of gains from falling international trade barriers (Atkin and Donaldson, 2015; Cosar and Fajgelbaum, 2016). More specifically for Africa, studies have shown that poor trade performance is related to weak infrastructure (Limao and Venebles, 2001), which limits firms' access to productivity-enhancing inputs (World Bank, 2017; Aggarwal et al., 2017). In this study, we use detailed data on infrastructure quality and travel distance between firms and ports to estimate a measure of port accessibility. This enables us to investigate the mediating role of distance between import competition and firm performance.

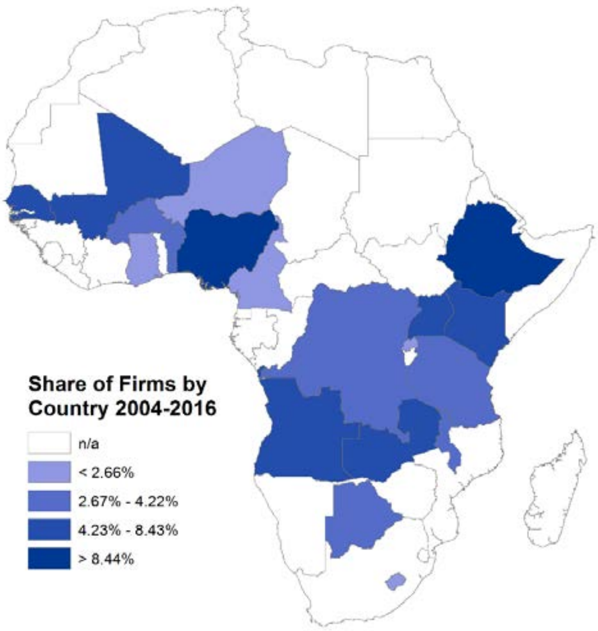
The remainder of the paper is structured as follows. Section 2 describes the data and discusses how variables are constructed. The empirical modelling strategy is presented in section 3, followed by a discussion of the results in section 4. The last section summarises and concludes.

2. Data

2.1. Firm-level Data

The main source of data for this study is the World Bank Enterprise Survey (WBES), a survey carried out to gather information on the business climate in developing countries. The survey provides a representative sample of private firms and collects detailed firm-level balance sheet data. A stratified random sampling technique based on firm size, geographical region and business sector is used. To construct our sample, we selected all countries in continental Sub-Saharan Africa that have been surveyed in at least two waves of the survey. By using firms' unique identifier, we create a firm-level panel dataset that consists of 2,820 firms across 19 SSA countries between 2004 and 2016.[1] As shown in Figure 3, most of the firms in the sample are located in Nigeria (16% of the total sample), Ethiopia (14%), Senegal (8.5%), Uganda (7.5%) and Angola (6.5%). These represent most of SSA countries actively engaged in international trade, and in particular with China, as shown in Figure 5.

Figure 3. Share of firms by country included in our sample.



[1] The countries included in our sample are: Angola, Benin, Botswana, Burkina Faso, Cameroon, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mali, Niger, Nigeria, Rwanda, Senegal, Tanzania, Uganda and Zambia.

Elaboration based on the World Bank Enterprise Survey database.

The WBES provides information on firm location, age of firm, number of skilled and unskilled employees, total sales, capital expenditure, costs of intermediate inputs of production and industrial sector at the 2-digit level.[2] There is also information on the export status of firms and ownership type. We consider firms to be exporters if they exported at least 1% of their annual production, with no distinction made amongst trade partners.

In this study, we focus only on firms in the manufacturing sector, as the overwhelming majority of Chinese imports to the continent are manufacture goods.[3] Figure 4 shows the distribution of firms in our sample by industry. Firms in food processing dominates the distribution and represents more than 15% of the total distribution of industries. Apparel industry makes up 7%, followed by manufacturing of consumer products (6%) and the production of metal products. It is also interesting to note that all these industries are particularly affected by competition from Chinese imports as shown in Figure 6.

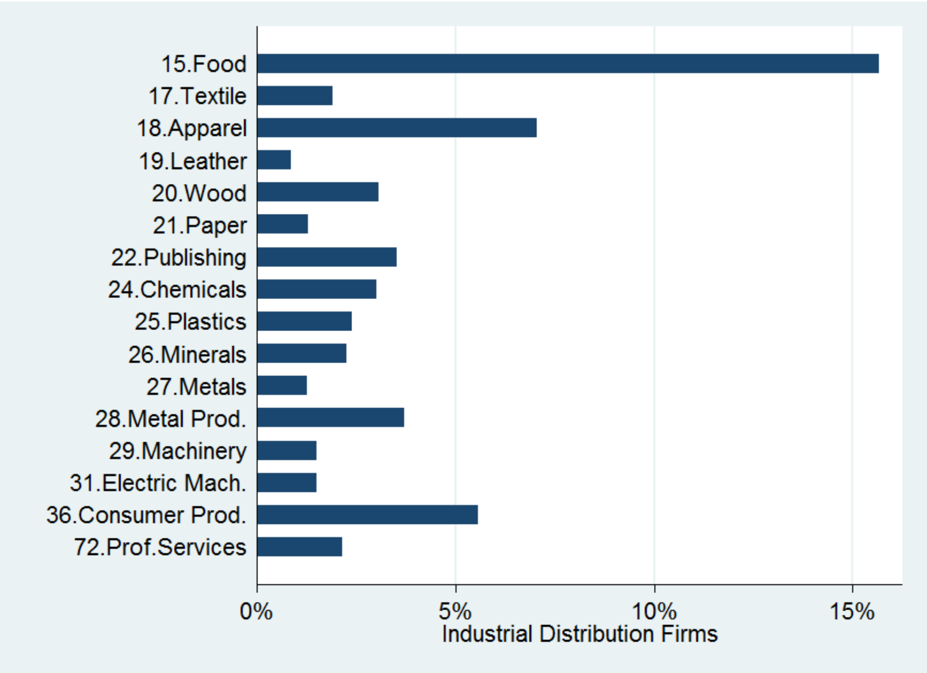


Figure 4. Distribution of firms by industry included in our sample.

Elaboration based on the World Bank Enterprise Survey database.

2.2. Trade Data

Since the World Bank Enterprise Survey data does not provide firm-level information regarding the value, classification and origin of imported products, we rely on the UN

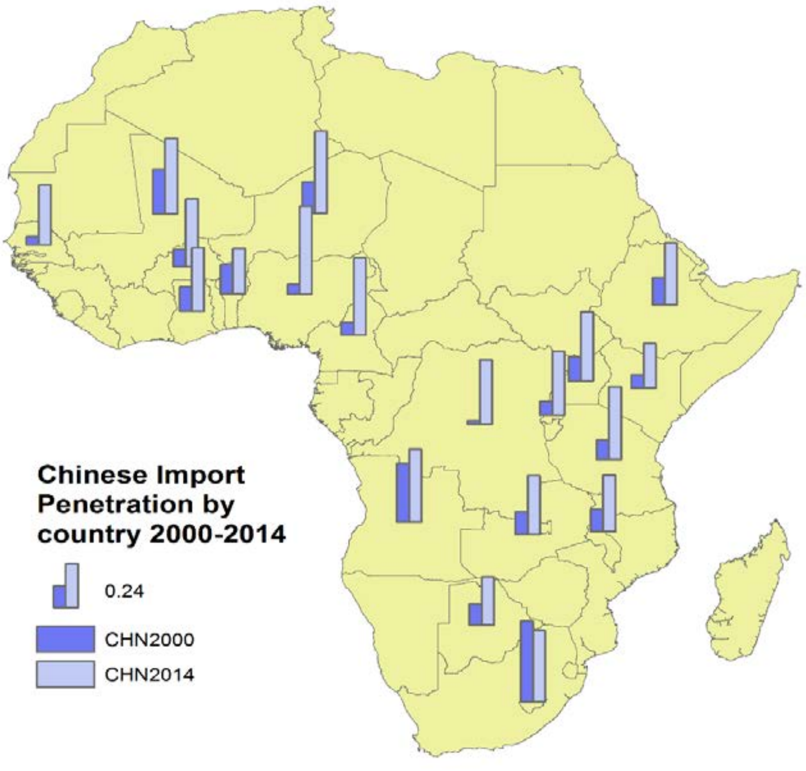
[2] All prices have been deflated to 2005 levels using the GDP deflator from the World Bank and then transformed into international US dollars using the Purchasing Power Parity (PPP) Index again obtained from the World Bank.

[3] As robustness check, we included firms from the services sector.

COMTRADE trade database to build a city-industry level measure of import competition from China. Figure 5 illustrates the distribution of Chinese imports competition across countries in the sample before China's accession to the WTO in 2001 and in 2014, as a comparison.

Chinese imports are measured as the share of imports from China over the total imports for each country in the sample. For most countries, there is a significant rise in the share of Chinese imports between 2000 and 2014, except for Lesotho and Angola. The landlocked status and its economic dependence on South Africa might be an explanation for the former, while the special trade and diplomatic relationships with China, as well as its specialization in natural resources industries, might be for the latter. Chinese import competition in 2014 seems particularly intense among ECOWAS (Economic Community of West African States) countries[4], particularly for Nigeria (48% of total imports), Niger (44%), Cameroon (42%) and Mali (40%) although import competition from China in all countries included in our sample is on average very high at almost 35%.

Figure 5. Chinese imports penetration by country 2000-2014.



[4] We split the SSA countries in three macro-regions: the Economic Community of West Africa States (ECOWAS) including Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo; the East Africa Community (EAC) including Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda; the Southern Africa Development Community (SADC) including Angola, Botswana, Comoros, Democratic Republic of the Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

Elaboration based on the UN COMTRADE database. Chinese import penetration measured as the share of imports from China over the total imports of each country in our sample.

The COMTRADE database provides detailed information on exports and imports of goods disaggregated by country and 2-digit industry classification.[5] For each country in the sample, we build two different measures of import competition: imports from China (CHN) and imports from the rest of the world (ROW), for 20 different manufacturing industries. Figure 6 shows that imports from China have increased in similar proportions between 2000 and 2014 across all industries. The intensity of imports from China is particularly concentrated in few sectors, mainly textiles, apparel and leather industries, the manufacturing of consumer goods and electrical machineries.

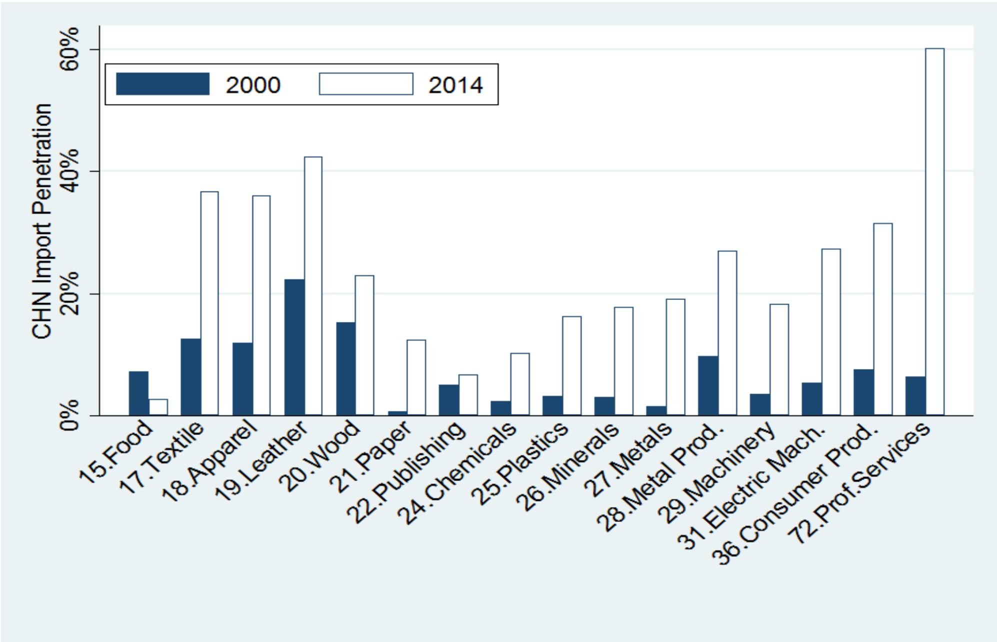


Figure 6. Chinese imports penetration by industry 2000-2014.

Elaboration based on the UN COMTRADE database. Chinese import penetration measured as the share of imports from China over the total imports of each country in our sample.

We follow Autor et al. (2013) and build a city-industry import competition variable, which weights the country-industry import variable with the share of each city (r) in the total employment of industry (s) and country (c) over time (t):

$$IPW\_CHN_{rst} = IMP\_CHN_{cst} \times \frac{EMPL_{rst}}{EMPL_{cst}} \qquad (1)$$

Using this approach enables us to proxy for the final destination of goods imported from China based on the relevance of each city in the overall country-industry employment.

[5] The import data is reported in US dollars in constant prices and we log-transform it in order to estimate the elasticities of different firm-level performance variables to variations in the import competition from China.

2.3. Trade Infrastructure, Distance and Gravity

SSA countries have notoriously high transportation costs due to very poor infrastructure networks, and a large fraction of the population living far from the coast (Teravaninthorn and Raballand 2009). Previous research on this topic has shown that poor transport infrastructure plays an important role in explaining economic performance and development of trade relationships in SSA (Iimi et al. 2017). Access to ports is particularly relevant for SSA countries, since they represent the primary trading connection with the rest of the world (Palsson et al. 2017). In fact, most of African international trade flows take place with oversea countries, since intra-continental trade among contiguous countries represented very tiny proportions of their total trade (Coulibaly and Fontagné, 2006). In addition, formal manufacture exporting activity is highly concentrated in the largest cities located on the coast of SSA countries, with hinterland cities having very little exposure to international trade (Jedwab and Moradi, 2016). Better access to ports could therefore improve firms' participation in international trade activities, not only by increasing the probability of exporting but also by facilitating the penetration of imported inputs of production in cities located in the hinterland and thus economic development (Behar and Venables, 2011; Herrera Dappe et al. 2017). For instance, recent empirical evidence for SSA counties has shown that an increase in transportation costs induces the income of cities near that port to increase much faster relative to otherwise identical cities located farther away (Storeygard, 2016).

For these reasons, we take into consideration how access to ports moderates the relationship between Chinese import competition and firm performance. To assess the mediating role played by accessibility and proximity to trade infrastructure, we rely on different sources of data on the quality of the road network in SSA and the location and characteristics of ports. This enables us to connect spatially distributed firms through a roads network to sea ports where Chinese imports are received.

2.3.1. Ports Data

We collect data on the geo-location, size and main characteristics of major ports in SSA from the World Port Index (WPI) data provided by the US National Geospatial-Intelligence Agency. This database contains the location, physical characteristics, facilities and services offered by major ports and terminals world-wide (approximately 3,700 entries). We identify 180 main ports for the African continent. This is further reduced to 70 ports once we remove ports that are classified as very small by the WPI and not deemed fit to host containerships. The WPI provides detailed information on the typology of the port (coastal natural, coastal breakwater, river port or open roadstead), the overall area size, wharf facilities and the depth of water at the anchorage, entry channel and cargo pier.

2.3.2. Ports Luminosity

To get information on the size and intensity of the activity of ports in SSA, we complement the WPI data using satellite data on night-light available from the US Air Force DMSP OLS database. Given the very limited micro-level economic data available for African countries, satellite data on light emitted into space at night has been found to be a good proxy for income growth and economic activity of cities, regions and countries (Henderson et al., 2012; Storeygard, 2016). Using this data allows us to estimate the dimension of ports and the intensity of their activity based on their luminosity at night.

These data are represented in a grid in which each pixel, corresponding to 30 arc-second or slightly less than a square kilometre at the equator, is given a light-intensity value. Night light emissions are a reflection of both indoor and outdoor lighting, which are connected to a plethora of different human activities and are likely to be influenced by economic activities across regions. Appendix A1 gives a more in-depth overview of the night-light data and about how the luminosity varies across the different countries used in this study. To estimate ports night-light luminosity (PNL), we first create two buffers of varying dimension encircling the port coordinate with the width of the buffer depending on port dimension obtained from the WPI.[6] Once buffers are constructed, we calculate the mean luminosity of the underlying area in the second step.

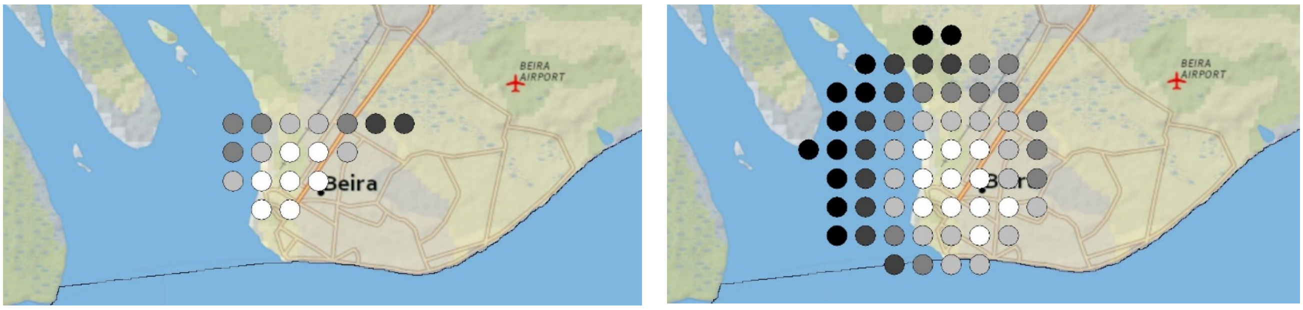


Figure 7. Port of Beira, Mozambique, mean and maximum dimension buffer, 2003.

Dimension and luminosity of the port of Beira when the mean and maximum buffers are used.

[6] Specifically, the average dimension is 1, 2 and 5 kilometres for small, medium and large ports respectively; the maximum dimension for the same categories is 2, 4 and 9 kilometres respectively.

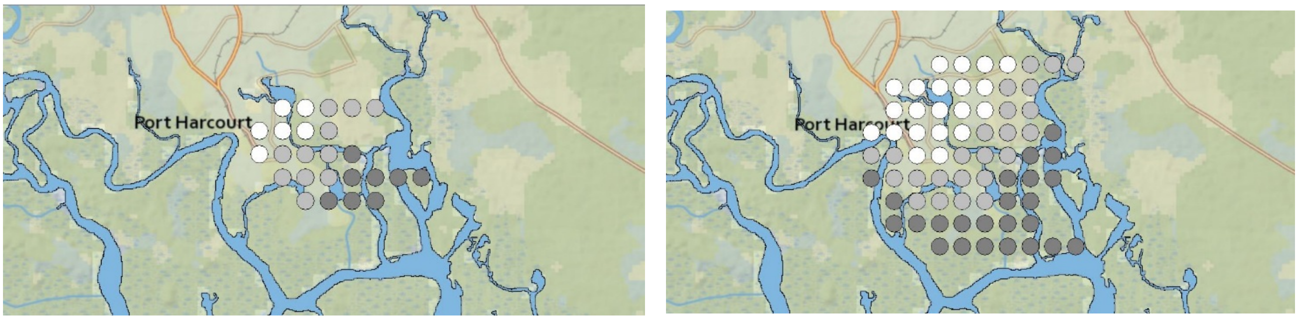


Figure 8. Port of Harcourt, Nigeria, mean and maximum dimension buffer, 2003.

Dimension and luminosity of the port of Port Harcourt when the mean and maximum buffers are used.

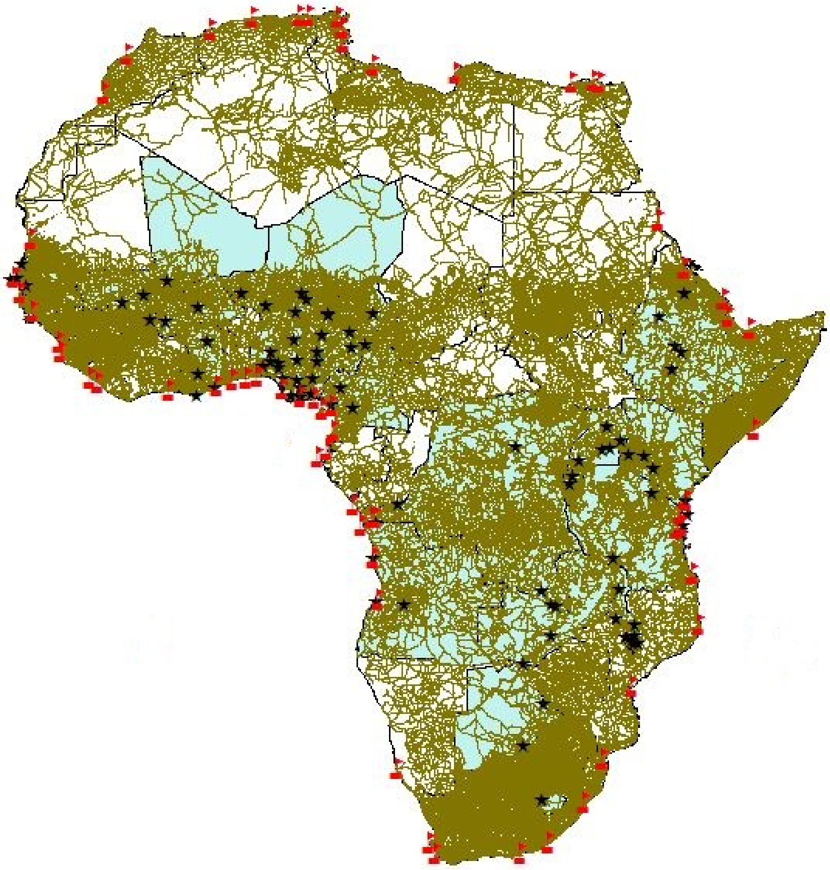
As an example, Figures 7 and 8 show the buffered area around the ports of Beira, Mozambique, and for Port Harcourt, Nigeria, when the mean and maximum dimensions are used. The maximum buffer always yields a dimmer luminosity as it is more likely that zones which are not part of the port are included. Regardless of the measure used, there is a clear evidence of increased luminosity across the period of consideration. Both measures were used as a robustness test in the empirical analysis.[7]

2.3.3. Travel Distance and Time

To determine the overall proximity and accessibility of cities to trade infrastructure, we use the GIS O-D (Origin-Destination) network analysis tool of ArcGIS to measure the driving distance between firms located in the different cities and ports using road network data. This data is provided by the Socio-Economic Data and Application Center (SEDAC) of the Columbia University Center for International Earth Science Information Network. Figure 9 presents the geo-location of the cities included in our sample (represented by the black stars) and the location of the main African ports included in the WPI data (in red) connected by the road network provided by the Columbia University.

[7] Table A1 in the appendix provides further illustration.

Figure 9. Road connections between cities and ports included in the dataset.



Elaboration based on SEDAC and WPI data.

Based on this, two indicators were derived: first, the driving distance for each city-port pair in kilometres, and second the driving time in minutes needed to cover that distance, based on speed limits, the quality of roads reported and road classifications.[8] For additional robustness, we also calculated the Euclidean straight line distance between all city-ports combinations in degrees using ArcGIS and additional measures of driving distance and time using the HERE mapping tool application.[9] The correlation between the five different measures of distance is high. As a result, we use driving time in minutes as our measure of distance in the main empirical analysis and the Euclidian straight line distance in degree for robustness tests.

2.3.4. Gravity and Ports Accessibility Index

Driving time may provide a reliable measure of proximity and accessibility and is an

[8] The network data provides 8 different roads classes for which the following speed limits have been assigned based on the information provided by the OpenStreetMap Wiki on “Africa Tagging Guidelines": highways 90km/h; primary 70km/h; secondary 60km/h; tertiary 50km/h; urban 30km/h; tracks 20km/h; service road 20km/h; unclassified 30km/h (http://wiki.openstreetmap.org/w/index.php?title=East_Africa_Tagging_Guidelines&oldid=1534648).

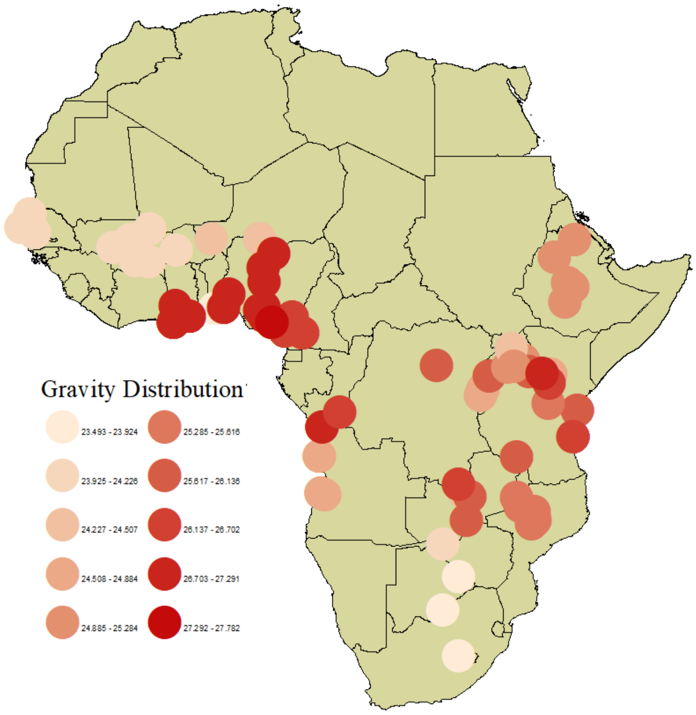
[9] This is available at https://www.here.com/en

improvement in respect to previous studies that use Euclidian distance or driving distance (NEEDS REFERENCE). However, t driving time does not take into account other elements that affects the connectivity of firms to ports, such as, the presence of national borders, the so-called "border effect", and other economic and political factors influencing the decision to use one port over another (McCallum, 1995; Havranek and Irsova, 2017). For this reason, we adopt the widely used structural gravity framework developed by Anderson and van Wincoop (2003) to estimate the gravity force between cities and ports based not only on their distance, but also on their economic size and other bilateral factors facilitating or impeding trade and transportation between cities and ports. To empirically estimate this attractive force, we run a fixed effect gravity model which requires a measure of economic flow between port of origin and city of destination and a vector of flow impediments and facilitators for each city-port pair at the city, port and country level of the form:

$$X_{rpt} = \alpha_0 + \alpha_1 DIST_{rpt} + \alpha_2 S_{rt} + \alpha_3 S_{pt} + \alpha_4 T_{rpt} + k_{rp} + k_t \qquad (2)$$

where the economic flow between each city-port, $X_{rpt}$is given by the interaction between the size of each port *p*, and the overall weighted import competition from all foreign countries for each city *r*. To explain this flow, we then account for several measures of trade attractiveness and impediments, following the standard trade gravity literature (REF needed). First, we include the driving time distance between cities and ports, $DIST_{rpt}$. Secondly, we consider the economic size of the destination, S_{rt}, in terms of total sales at the city-level, destination country GDP per capita and population. Third, the economic size of the port of origin, S_{pt}, captured by the level of economic activity of the port and is measured by the average luminosity across time, the origin country GDP per capita and population. Finally, we include a set of bilateral trade impediments and facilitator dummies for each origin-destination country pair obtained from the CEPII database. These include the presence of borders, common language, past colonial relationships and whether or not country pairs have similar legal systems. Other dummies included are common free trade agreements (FTAs), currency unions and membership to the WTO. Table A2.1 in the appendix show the results of the gravity model – there is a negative impact of distance on economic flows between ports and cities, and a positive relationship with the economic size of both ports and cities. The results for the other control variables are in line with the literature. .

Figure 10. Distribution of the ports accessibility index (PAI) for all sampled cities



The results from the gravity estimation enable a computation of the overall ports accessibility index (PAI) for all cities in the sample across time, PAI_{rt}. We do this by averaging the predictions of the gravity model by city and year, with higher values indicating that these cities are better connected to ports and lower values indicating poorer port accessibility. Figure 10 shows the distribution of PAI. Including all city-ports combinations to calculate PAI may lead to inaccurate estimates because, imports would be shipped to ports closer to the final destination. As a robustness test, we limit the estimation of PAI to only city-ports routes within a travel time distance of 1, 2 or 3 days. This represents approximately the first 10^{th}, 25^{th} and 50^{th} percentiles of the overall travel time distribution. The results of sensitivity tests performed using the different travel radius are presented in Table A2.7 in the appendix and are robust to different accessibility measures.

3. Methodology

To estimate the impact of Chinese imports competition on the performance of manufacturing firms in SSA, we estimate a multi-level dynamic model with firm fixed-effects of the form:

$$Y_{it} = \beta_0 + \beta_1 IPW\_CHN_{rst-1} \times PAI_{rt} + \beta_2 X_{it} + j_t + j_s + j_r + \varepsilon_{it} \qquad (3)$$

where Y_{it} represents the different measures of firm *i*'s performance at time *t*. We measure firm performance mainly in terms of Total Factor Productivity (TFP)[10] and the intensity of skilled

[10] TFP is estimated following the methodology developed by De Loecker (2011) which is an extension of the standard Olley and Pakes (1996) methodology, taking into consideration the heterogeneity in terms of productivity between

workers (SKILL) measured as the share of skilled workers over the total number of production workers. As additional robustness tests, we look at the impact of Chinese import competition on firms total sales (SALES) and total employment (EMPL).

The coefficient of interest β_1 captures the effect of the interaction between the weighted import competition from China at the city *r* industry *s* level at time *t-1* IPW_CHN_{rst-1} and the port accessibility index for each city *r* PAI_{rt}. We also include in our estimation a vector X_{it} of firm-level characteristics including total sales (SALES), productivity (TFP), total employment (EMP), export status (EXP), capital expenditure (K_EXP), average wages (WAGE) and firm age (AGE).[11] In addition, we include year j_t, city j_r and industry SIC 2-digit level, j_s dummies.

Table 1. Firm-level summary statistics

Variable	*No. Obs.*	*Mean*	*S.D.*	*Min*	*Max*
TFP	2,105	10.567	3.256	-2.152	24.105
IPW_CHN	2,105	15.564	2.221	7.332	21.042
IPW_ROW	2,105	17.857	2.617	0.000	21.777
SALES	2,105	13.529	3.541	0.000	27.122
EMPL	2,105	3.216	1.326	0.693	11.067
WAGE	2,105	8.092	2.979	0.000	17.991
AGE	2,105	2.632	0.726	0.000	5.118
EXP	2,105	0.235	0.424	0.000	1.000
K_EXP	2,105	7.251	8.063	0.000	24.530
SKILLED	2,105	0.683	0.297	0.000	1.000
PWD	1,945	12.324	0.202	11.936	12.809
PNL	1,945	6.497	0.167	6.098	6.754
PAI	1,945	25.168	1.412	21.850	27.773

We employ a multilevel regression analysis to take into consideration the fact that our parameters vary at more than one level - starting from the lowest at the firm level and then aggregating up to the city, industry and country level. Multi-level models provide a practical tool to assess the extent to which a link exists between the "macro" variables at the regional-industry level and performance and the economic performance of firm at the "micro" level. Multilevel models have recently found application in regional economics in particular to assess how firm behaviour is affected by macro regional phenomena (Raspe and Van Oort, 2007). These models are particularly fitted for spatial analysis, where the particular geography of an economic region can be considered as a higher level effect on firm production decisions and performance. In this regard, multi-level

exporters and domestic firms. We estimated TFP by industry and country using value added as a proxy for output, including in the estimation total employment as a measure for labour, the total costs of intermediate input as costs of production, an export dummy equal to 1 for exporters or 0 otherwise, and total investment in tangible and intangible assets. Once estimated and logged, we remove the top and bottom percentiles without any significant loss of observations in order to mitigate the effect of outliers on our analysis.

[11] In each specification, we exclude the control variables when they are the dependent variables.

models present a number of benefits compared to more traditional linear methods. First, they recognise the hierarchical nature of the data, relaxing the stringent assumption that observations within sub-units are zero-correlated, and it allows the analysis of the level specific variability of output both through mean and the slope effects, and last but not least it avoids endogeneity issues between the observational unit and the variables of interest (Srholec, 2010). As a robustness test, we use standard OLS models including firm-level fixed-effects. Results from these estimations are reported in Tables A2.4 and A2.5 in the appendix

As identified in most of the trade literature on the impact of trade liberalization on economic performance, import competition from China cannot be considered exogenous to many of the outcome variables of interests (Bloom et al., 2015). The potential endogeneity of imports stems from different sources, such as the reverse causality of more productive firms opening up to international trade, the self-selection of more competitive firms in industries that are more affected by Chinese import competition and the endogenous decision of firms to locate in cities with a better accessibility to ports. In addition, while trying to establish a relation between Chinese import competition and firms' performance, our analysis might also be affected by the presence of unobservable characteristics correlated with both the exposure to Chinese competition and the performance of Sub-Saharan African firms.

To avoid the issue of endogeneity, we follow recent contributions in the literature, by developing a time-varying instrument for Chinese imports, and trade more generally, based on an interaction between an exogenous geographic characteristic and a shock to transportation technology that affects trade partners differently (Feyrer, 2009; Pascali, 2017). The geographic characteristic that we exploit is the presence of coastal features which determine the depth of waters in ports in SSA. The technological shock is the development of container ships size since the mid-1990s.

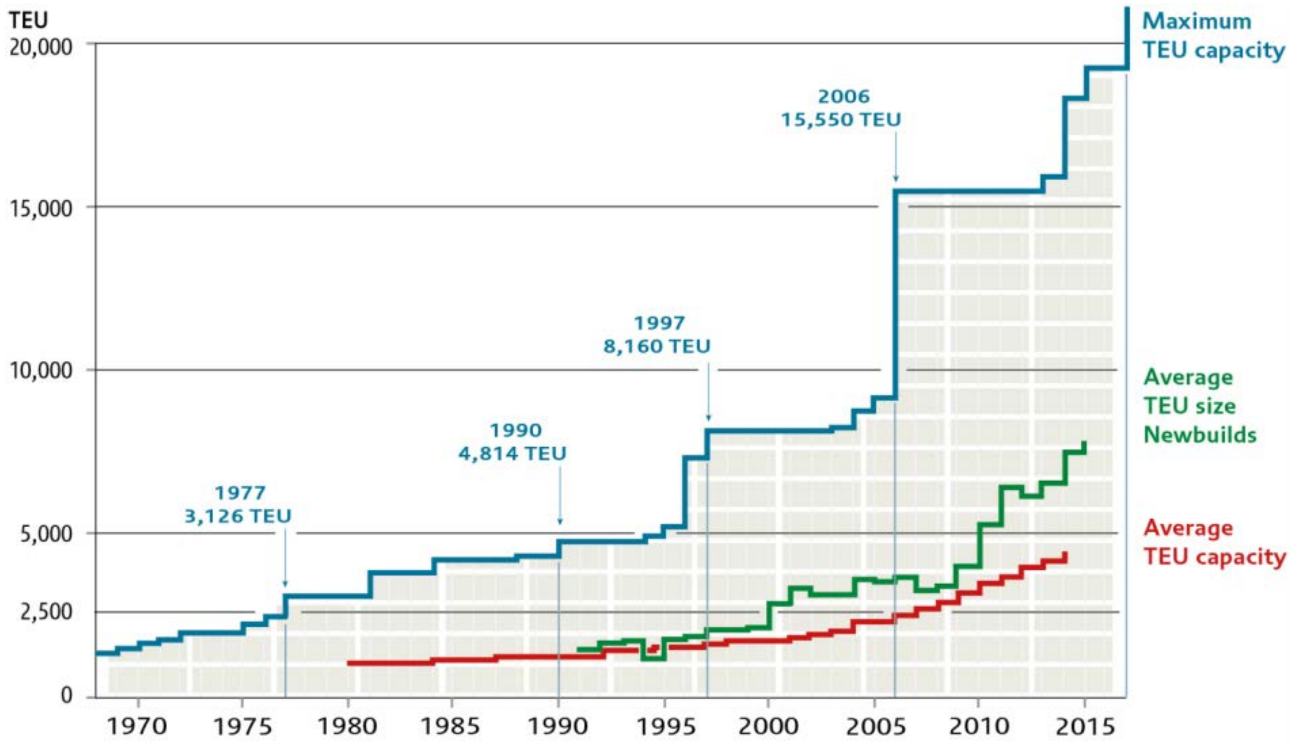


Figure 11. Development of containership size since 1970s.

Source: OECD-ITF (2005) based on data from Clarkson Research Services.

As shown in Figure 11, after the mid-1990s the maximum capacity of containerships has almost quadrupled, from around 4,800 TEU at the beginning of 1990s up to around 21,000 TEU by 2016, mainly due to the introduction of the "Post-Panamax containerships" (OECD-ITF, 2015).[12] As a growing number of larger container ships were built over time, the average TEU capacity of world cargo fleet also increased from 1,250 to 4,500 TEU between 1990s and 2016. Interestingly, this exogenous transportation technology has developed almost contemporaneously with the expansion of the exports of China towards the rest of the world after the WTO accession in 2001. Given the geographical distance and the lack of alternative transportation modes, it is plausible to assume that the vast majority of the China-Africa trade flows take place through container ships, beyond the average 75% of global trade volume and 60% of trade value (UNCTAD, 2014).

The rationale for interacting these two variables is that new larger containerships introduced after 1995 will need deeper waters for the anchorage, loading and unloading operations in ports. The identification strategy then relies on the assumption that the same transportation shock has a differentiated impact on different countries and cities due to their proximity to ports characterised

[12] TEU stands for a Twenty-foot Equivalent Unit, a unit of cargo capacity generally used to describe the capacity of container ships and container terminals. It is based on the volume of an internationally standardized intermodal container, 20-feet-long (6.1 m) and 8-feet-wide (2.44 m). No precise standard exists on height, although in general the most common height is 8 feet 6 inches (2.59 m), to fit into railway tunnels.

by some exogenous geographic features. In particular, the impact of the transportation shock is not homogeneous across export destinations, since it depends on the presence of ports with a certain depth of water, which are in turn determined by an exogenous geographic characteristic, i.e. the presence of coastal features allowing for deep waters to accommodate the new larger container ships.

Empirically, we construct the ports water depth (PWD) instrument for Chinese imports competition by first interacting the time-varying average size of container ships available each year from the ITF-OECD (2015), with the exogenous time-invariant depth of water at the anchorage point and the overall size, provided by the WPI for each port in our sample.[13] Secondly, we weight the depth of water for each port by the gravity force between each city-port pairs and then average up by city in order to build a city-level instrumental variable. A valid instrument should be correlated with the endogenous variable (the competition of Chinese imports) but without any direct effect on the outcome variable (e.g. the performance of individual firms) after controlling for other covariates. Our instrument satisfies the exclusion restriction condition, as the shock affects Chinese imports towards different African partner countries in different ways. That is, it increases imports competition relatively more towards cities that are closer to ports with deeper waters, as these are the only ones that can accommodate larger container ships, thus, affecting the performance of firms only through the increase in the import flows of Chinese goods transiting through the ports. Table A2.3 in the appendix shows the results of the first stage IV multi-level estimations, and the test for exogeneity and validity of the instrument. As robustness test, we estimate the model by using a 2SLS estimation model with firm fixed-effects. Results from these estimations as shown in Table A2.5 in the appendix are consistent with the findings from the multi-level estimations.[14]

4. Results

Table 2 presents findings from the multilevel IV estimations.[15] The results in column 1 show a positive effect of imports from China on the productivity of SSA firms. This is consistent with theoretical literature on the impact of trade liberalization, that greater exposure to trade forces less

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[13] It is only very recently, and only in the most advanced African countries, that some large infrastructural investments have been undertaken to artificially increase the depth of waters in African ports, mainly in some North-African countries (Morocco and Algeria) and in South-Africa (USITC, 2009; ICTSD, 2017)

[14] As an additional robustness test, in Table A2.6 in the appendix we report the results of the instrumental variable approach using as an instrument for Chinese import competition the variation of the luminosity of the ports over time. This instrument should also satisfy the exclusion condition, as the only way the luminosity of ports could affect the performance of firms is through import of Chinese goods transiting through the port. An increase in night luminosity can be used as proxy for how busy ports are, determined in turn by the large inflow of Chinese goods. However, it might be argued that port luminosity is a proxy for the quality of the electricity infrastructure or of economic activity altogether, therefore having a direct impact on firms' productivity. A potential way to satisfy the exclusion restrictions in this case would be to exclude from the IV analysis the subsample of firms located in the same cities of the port (almost 17% of the sample), thus using ports nightlights only as an instrument for firms located in non-coastal cities.

[15] Results for the simple multi-level analysis and for the first stage of the IV estimations available in Tables A2.2 and A2.3 in the appendix.

productive firms to exit the market, thus triggering a within-industry reallocation of capital and resources towards the more productive surviving firms (Bernard, Jensen and Schott, 2003; Eaton et al. 2007). The result of a productivity-enhancement effect of imports from China have been found previously for other developing countries (Pavcnik, 2002; Bustos, 2011). Unfortunately, we are unable to directly test the effect on exiters, since our data is limited to only surviving firms.

Table 2. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: IV Multi-level regression with firm fixed-effects

IV Multi-level	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	0.448**	0.0374**	-0.247*	0.0933***
	(0.218)	(0.0147)	(0.119)	(0.0139)
SALES	1.004***	-0.0224**		0.552***
	(0.0129)	(0.00878)		(0.0154)
EMPL	-0.709***	-0.0307***	0.771***	
	(0.0346)	(0.0108)	(0.0267)	
WAGE	-0.131***	0.00162	0.258***	-0.179***
	(0.0168)	(0.00519)	(0.0137)	(0.0121)
AGE	0.00616	0.00436	0.00720	0.195***
	(0.0335)	(0.0113)	(0.0294)	(0.0253)
EXP	-0.0384	0.00208	0.184***	0.312***
	(0.0667)	(0.0200)	(0.0570)	(0.0447)
K_EXP	-0.0240***	-0.000633	0.0219***	0.00412*
	(0.00295)	(0.000994)	(0.00257)	(0.00221)
TFP		0.0176***	0.748***	-0.344***
		(0.00649)	(0.00999)	(0.0138)
Observations	1,945	1,945	1,945	1,945

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Secondly, imports from China are also positively related to the increase in the share of skilled workers as shown in column 2. Increased Chinese competition enables surviving firms to increase the share of skilled workers by almost 4 percent, thus allowing firms to shift production from low-skill to high-skill-intense products (WITS, 2017). Imports from China can therefore enable firms to change their input mix from the use of domestic inputs to higher quality and cheaper foreign inputs. Thus, competition can foster technological change and lead to increased demand for skilled labour (Guadalupe, 2007; Bloom et al., 2011).[16]

Columns 3 and 4 show the effects of Chinese competition on sales and employment

[16] Table A2.6 in the appendix reports the results of the multi-level IV approach using luminosity (nigh-lights) around the ports as an alternative instrument for Chinese imports. The results from these estimations are consistent.

respectively. In column 3, there is a negative impact on sales of surviving firms. Competition from Chinese imports thus erodes sales of domestic firms. Column 4 shows evidence of a within-industry reallocation of resources from least productive to more productive firms. Specifically, increased competition from China imports could increase the size of surviving firms, in terms of employment, through several channels. First, surviving firms might absorb part of the workers displaced after the closure of least productive firms pushed out of the market because of the tougher Chinese competition. Secondly, surviving firms may be able to employ a larger number of skilled production workers who are able to facilitate production of more advanced products. Overall, these results suggest that surviving firms become larger and more productive, despite a reduction in total sales.

It could be argued that the impact of Chinese imports might not be different from the more general trade liberalization competition that originates from other developed and developing trade partners. We therefore examine whether trade from other partners have any significant impact on firm performance. To do this, we conduct a placebo test that uses imports from the Rest of the World (ROW) in the multi-level IV estimation.

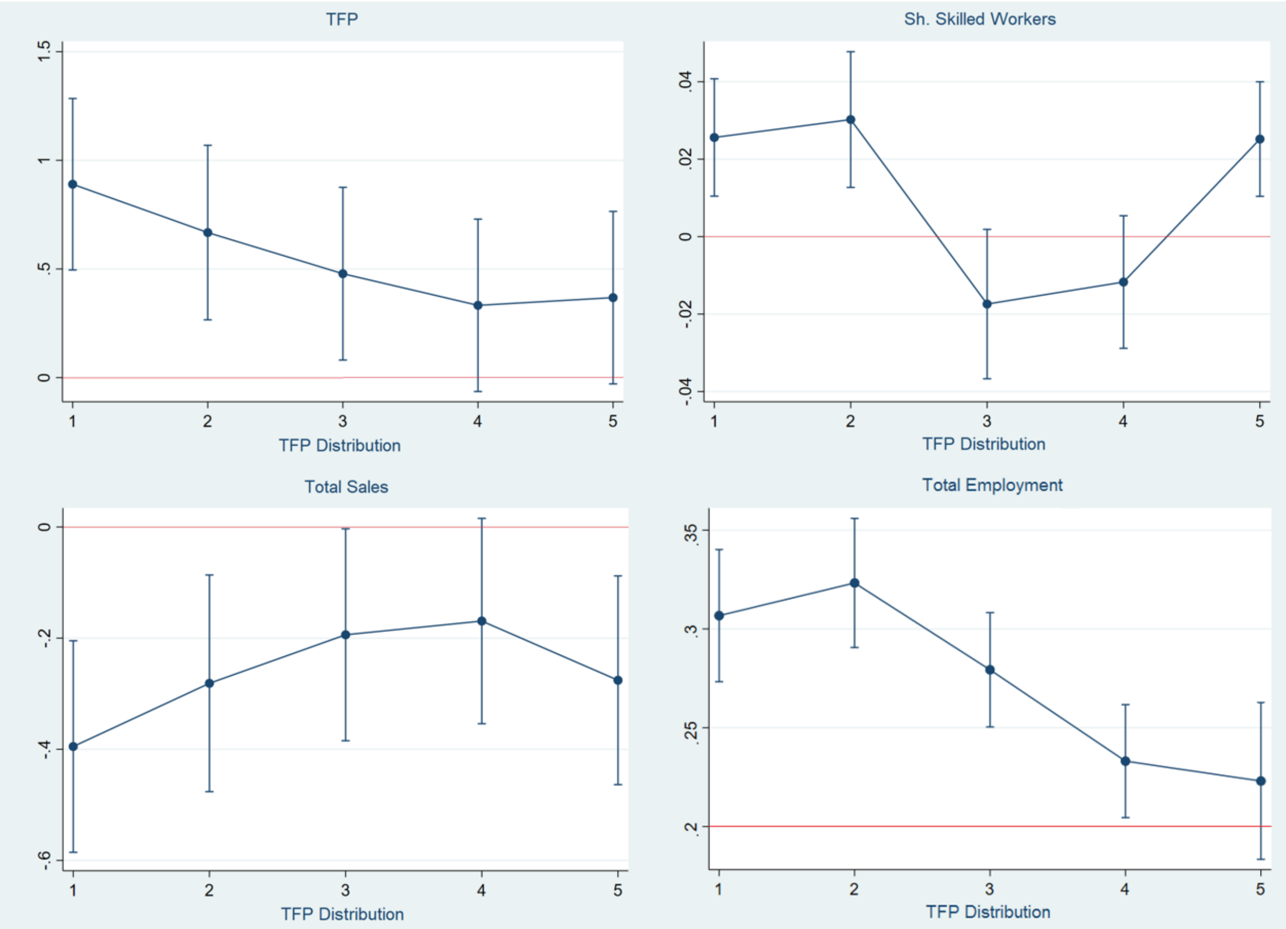
Table 3. Impact of imports competition from the ROW on the performance of Sub-Saharan African firms: IV Multi-level regression with firm fixed-effects

IV Multi-level	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	0.158	0.00398	-0.00789	-0.0143
	(0.111)	(0.0133)	(0.0885)	(0.0568)
SALES	1.033***	-0.0206***		0.582***
	(0.0138)	(0.00796)		(0.0144)
EMPL	-0.734***	-0.0326***	0.816***	
	(0.0265)	(0.00988)	(0.0189)	
WAGE	-0.0201**	0.00677**	0.0744***	-0.0489***
	(0.00981)	(0.00312)	(0.00806)	(0.00713)
AGE	-0.0419	0.00598	0.0382	0.155***
	(0.0335)	(0.0114)	(0.0281)	(0.0247)
EXP	-0.0636	0.00250	0.129***	0.348***
	(0.0586)	(0.0199)	(0.0492)	(0.0425)
K_EXP	-0.0293***	-0.000843	0.0274***	-0.00127
	(0.00297)	(0.000999)	(0.00250)	(0.00218)
TFP		0.0156**	0.725***	-0.366***
		(0.00668)	(0.00963)	(0.0139)
Observations	1,945	1,945	1,945	1,945

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Results from these estimations are reported in Table 3. Across all specification, there are no significant effect of imports from ROW on firm performance. This finding suggests the relative uniqueness of trade with China for productivity-enhancement effects for SSA firms. In addition, these results might suggest a declining relevance of trade relations between SSA and ROW, thus highlighting how China is replacing the traditional trading partners of African countries, especially the former European colonizers.[17]

Figure 12. Heterogeneous impact of Chinese imports competition on the performance of Sub-Saharan African firms across the distribution of firms TFP



Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects.

According to the trade literature, trade liberalization could have a heterogeneous effect by affecting performance of firms differently (Lileeva and Trefler, 2010). Thus, the positive impact of imports from China on the performance of surviving firms may not be homogenous across firms. For this reason, we examine the heterogeneous effect of trade liberalization on the performance of firms across the distribution of firms' Total Factor Productivity. Figure 12 illustrates the estimated

[17] Related to this topic see analysis by Campbell (2008), Keers and Pennink (2016), Grimm and Hackenesch (2017) and https://www.nytimes.com/2017/05/02/magazine/is-china-the-worlds-new-colonial-power.html

marginal effects of Chinese import competition on the different measures of firms' performance across five quintiles of firms' initial productivity, from the bottom (q1) to the top (q5). Overall, the impact of Chinese imports competition is particularly relevant for surviving firms in the bottom two quintiles of the productivity distribution for all the measures of performance. Firms at the bottom of the distribution tend to be those that suffered the most, in terms of reduction of total sales. However, the same group of laggard firms experienced a much larger increase in productivity, enabling such firms to catch up in relation to firms at the top of the TFP distribution. This evidence is consistent with previous studies (Topolova and Khandelwal, 2011; Bigsten et al., 2016). The productivity catch-up of laggard firms could be driven by an increase in the share of skilled workers in the production processes, which we find to be larger for firms at the bottom of the TFP distribution. These surviving firms, also tend to experience higher levels of productivity. The particularly acute effect of the Chinese competition for firms at the bottom two of the distribution is also evident when examining the heterogeneous effect on total sales and employment.

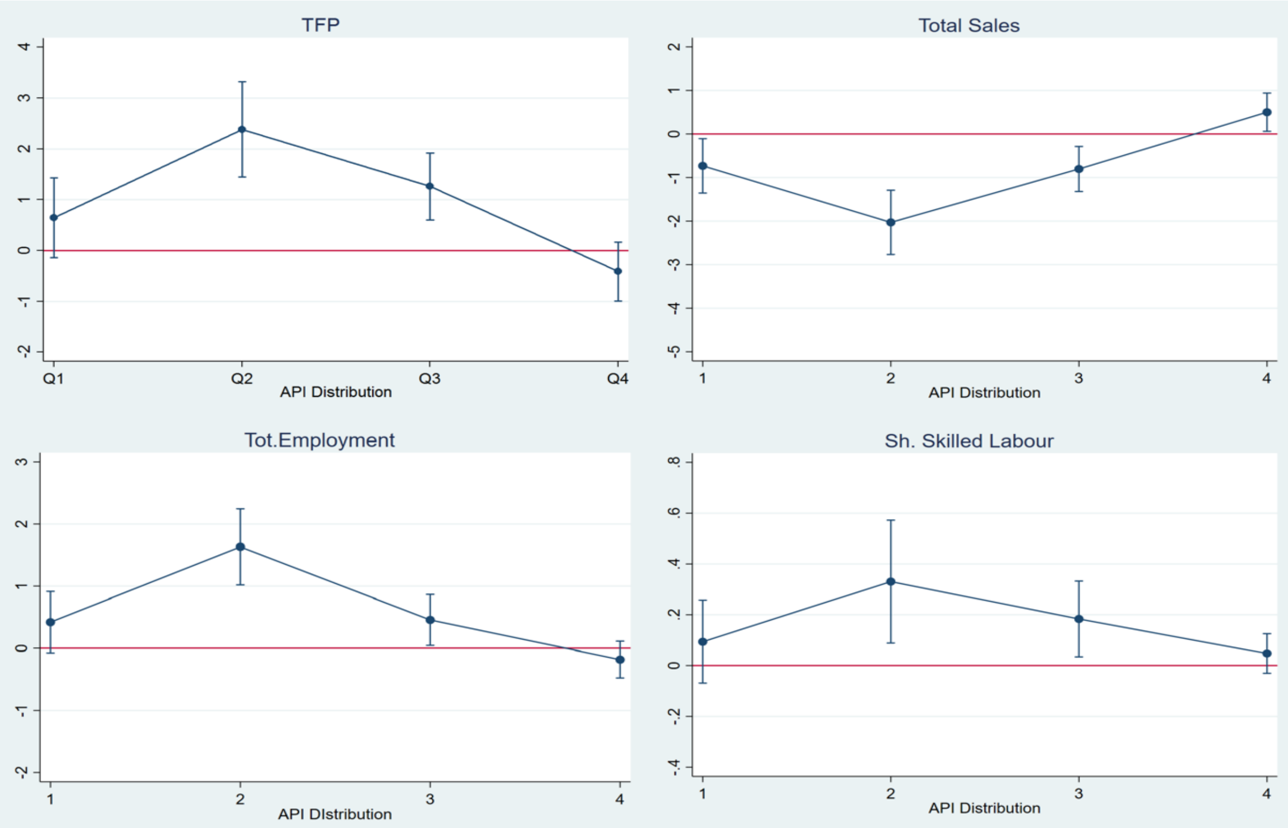
Finally, to examine the moderating role of ports accessibility on the performance of SSA firms, Figure 13 shows results of the marginal effects of Chinese imports on firm performance across the distribution of PAI, derived from the gravity model. Firms in the bottom quartile (q1) are located in more remote areas with limited access to ports, whilst firms in the top quartile (q4) are firms with better connection to ports.[18]

Overall, the results show a stronger positive impact on performance for firms in the second quartile of PAI distribution, with a positive productivity effect also for firms in the first quartile of the TPF distribution. The productivity effect of import competition decreases for firms in closer proximity to ports. This is an indication that Chinese imports have stronger effects in areas that are usually less exposed to international competition, while both better connected locations and isolated cities do not seem to be significantly affected by increased imports from China.

The plots of the marginal effects in the top-left graph of Figure 13 show that the impact of Chinese imports on domestic firms' productivity is positive only for firms in the second and third quartile of the API distribution. The heterogeneous effect on productivity is consistent with the impact on other measures of firms' performance -firms in the second bottom quartile of the API distribution experience a larger negative impact on sales. However, this group of firms reacts both by increasing thei size of their labour force, possibly by absorbing part of the workers freed by the exit of least productive firms, and by increasing the intensity of skilled workers employed in the production process.

[18] As a robustness check, we restrict the measure of the port accessibility index by including only ports that are within 3 days travel distance from the cities where firms are located. Results of this is in Table A2.7 of the appendix.

Figure 13. Heterogeneous impact of Chinese imports competition on the performance of Sub-Saharan African firms across the PAI distribution



Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects.

The results so far suggest that, Chinese imports have triggered a pro-competitive effect for firms with lower access to ports, and have resulted in a catch-up in performance for less productive and less trade-exposed surviving firms. Secondly, this evidence suggests that better infrastructure that decrease the cost of intra-national transports to ports could increase competition by providing better access to foreign intermediaries, with consequent benefits for firms located in remote area. Our findings highlight the importance of transport infrastructure in SSA countries, and suggests that gains from Chinese import competition could be uniformly distributed across hinterland regions that are usually not exposed to international markets.

5. Conclusions

Chinese import competition has increased significantly in SSA and other parts of the world over the last few decades. In Africa alone, imports of manufactured goods from China increased more than 50 times since the accession of China to the WTO. In this study, we provide new insights on Chinese import competition in SSA and its implications on performance of firms, using trade, firm and geographic data. A unique contribution of this study is the consideration of the role of infrastructure in moderating the relationship between Chinese import competition and firm performance. The results showed robust and compelling evidence of the overall positive effects of Chinese imports competition on productivity, acting mainly through the erosion of market shares, especially of least productive firms, forced to exit the market. However, this might also trigger a reallocation of resources towards the more productive surviving firms, leading to an increased size and the use of a larger share of skilled workers. The results also indicated that Chinese import competition did not have homogenous effects on firm performance, with firms located closest and furthest away from ports experiencing a weaker effect that those in the middle quartiles. The finding that firms located in comparatively remote areas can benefit from competition highlight the importance of transport infrastructure in SSA countries. Improvement in transportation links and infrastructure can be a stimulus for firm performance and economic development.

Overall, our findings reveal that Chinese import competition in SSA can be viewed as an opportunity for firms enhancement and can serve as a stimulus for economic growth and development. Parts of our results do not support earlier findings from the literature of a reduction in employment growth and skills (Mion & Zhu 2103; Álvarez & Claro 2009). The positive employment and skill effects that we find may be associated with recent improvements in educational attainment and skills development in SSA countries (Mijgaard & Mingat, 2012) that fosters growth and productivity. Our results also have important economic and policy implications. Concerns about labour displacement and possible firm closures may inhibit governments from encouraging domestics firms to embrace foreign competition. Our results however highlight that competition from Chinese firms has a positive effect on the productivity of surviving firms and on the skill quality of their workforce. Furthermore, the results also clearly indicate that surviving firms increase the size of their workforce, but as the data do not allow for an estimation of firms' survival rate we cannot determine if the economy wide employment effect is negative or positive. Further empirical investigation is needed to better analyse this nexus, which has important implication for the overall welfare impact of the China-Africa trade relation. Regardless, it is clear that many African economies stand to receive positive gains from an increase in productivity in their manufacturing sectors and in skills of its workforce, and these must also be borne in mind by governments when assessing the value of their trade relations with China.

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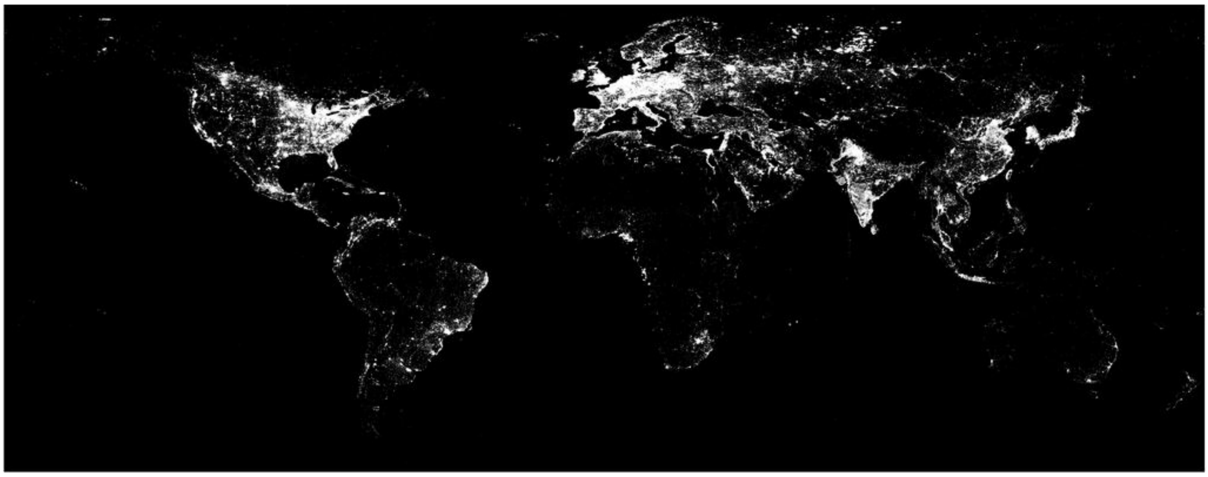
Appendix

A1. Nightlights Data

We complement the WPI data by relying on night-light satellite data provided by the US Air Force DMSP OLS database registering the emission of light from earth. The OLS sensor mounted on the satellites are able to pick up very low intensity visible and near-infrared (VNIR) light sources and thermal infrared, a range covering from fires and moonlit clouds to city lights. Data is first processed by the satellites and then further processed by researchers at NOAA, who clean them from a series of spurious light emissions which might be due to forest fires, auroral activities or other sources, so that man-made light remains the main source of emissions picked up. The presence of cloud cover is also taken into account, as heavy clouds might restrain the ability of the sensor to pick up VNIR emissions and light cloud cover might instead diffuse light creating a further source of spurious emissions. The final dataset are then constructed as an average over all nights of all orbits of each satellite, and can be accessed either in their raw format (i.e. as taken by the satellites, including light by fires, auroral activities etc.) or in their processed version, called "stable lights", which is the one used in this study (an example for the year 2003 is presented in figure A1.1, while figure A1.2 shows only the African continent).

Figure A1.1. DMSP OLS, 2003.



DMSP OLS stable light composite for the year 2003.

These data are represented in a grid in which each pixel, corresponding to 30 arc-second or slightly less than a square kilometre at the equator, is given a light-intensity value as a six-bit digital number, which is an integer ranging from 0 (or no lights) to 63. This night light emissions are then a reflection of both indoor and outdoor lighting, which are connected to a plethora of different human activities and are likely to be influenced by socio-cultural characteristics varying across the world, so that cross country analysis has to account for these.

Figure A1.2. DMSP OLS, African continent.

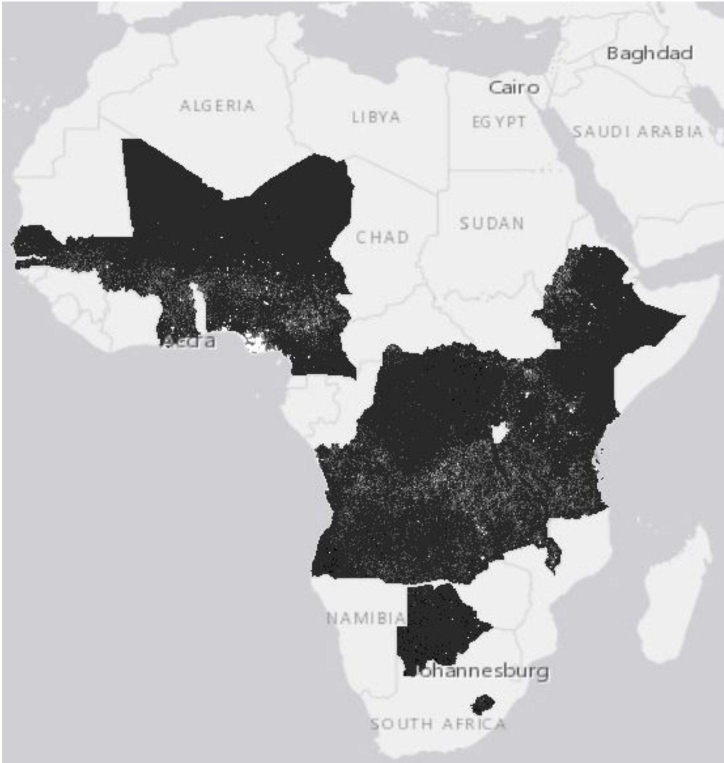
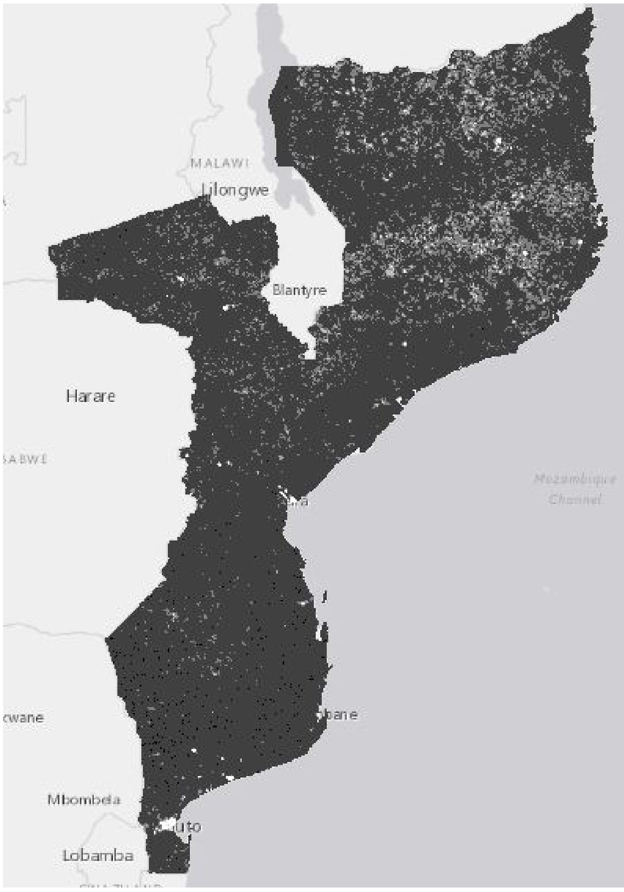


Figure A1.3. DMSP OLS, sampled countries.

DMSP OLS stable light composite for the African continent and sampled countries in the year 2003.

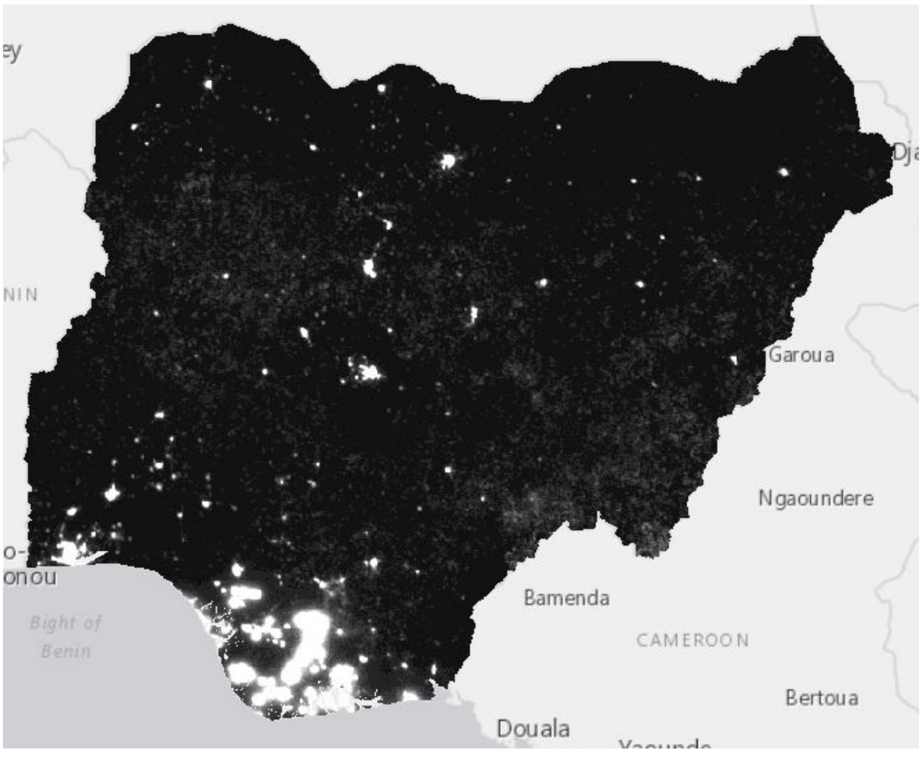
To give an overview of how data vary across countries, Table A1.1 presents the distribution of the digital numbers both for the whole set of countries analysed in the study (including those for which ports information are used) and for 3 selected countries for the year 2003, while figure A1.2 to figure A1.6 presents their respective DMSP OLS pictures for the same year. As it is apparent from Table A1.1, the vast majority of the pixels from both the whole region included in the study and for selected countries are completely unlit, principally as a consequence of the very low density of population of most African states. For this reason, in addition to the simple average luminosity we also report the average figures excluding unlit cells, which offer a clearer indication of the different level of competition of electric lighting amongst countries in the sample.

Figure A1.4. DMSP OLS, Mozambique, 2003.



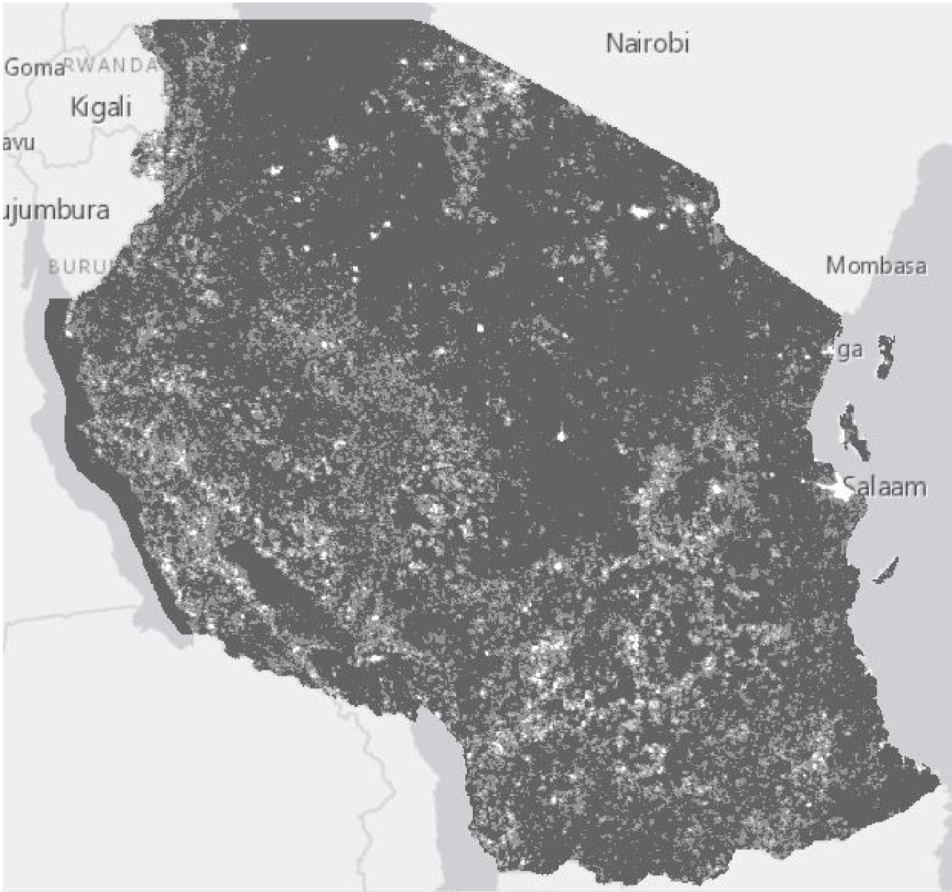
DMSP OLS stable light composite for Mozambique, year 2003.

Figure A1.5. DMSP OLS, Nigeria, 2003.



DMSP OLS stable light composite for Nigeria, year 2003.

Figure A1.6. DMSP OLS, Nigeria, 2003.



DMSP OLS stable light composite for Tanzania, year 2003.

Table A1.1. Distribution and average luminosity in countries included in the city-port sample and for selected countries, 2003.

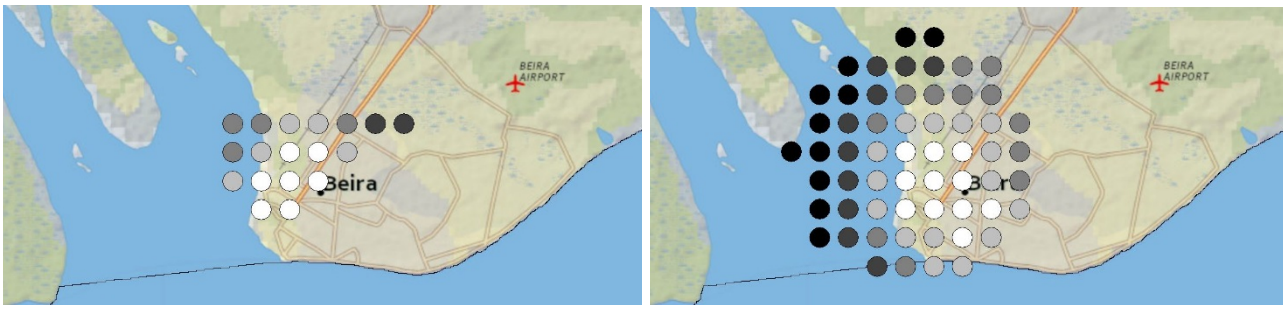
	SSA	Mozambique	Nigeria	Tanzania
0	92.26%	99.40%	90.94%	99.22%
1-5	7.24%	0.44%	4.78%	0.57%
6-10	0.23%	0.08%	1.89%	0.11%
11-20	0.12%	0.04%	1.08%	0.06%
21-62	0.13%	0.05%	1.27%	0.04%
63	0.00%	0.00%	0.04%	0.00%
Average	0.2484	0.0444	0.9926	0.0539
Average (excluding 0)	3.2113	7.3707	10.9501	6.8741

Summary statistics of DMSP OLS luminosity value for all countries included in the city-port sample and for selected countries.

Port Luminosity

To obtain the average luminosity value for all ports included in the study we proceeded in two different steps. The first step was the creation of two buffers of varying dimension encircling the port coordinate obtained from the World Port Index, with the width of the buffer depending on port dimension. As the dataset contains information about ports' dimension only for a subset all existing ports, we could not use the specific measure of all ports included in the study. However, the dataset classifies all ports as small, medium or large, so we decided to calculate both the average and the maximum dimension for each category using data from all African ports. Specifically, the average dimension is 1, 2 and 5 kilometres for small, medium and large port respectively; the maximum dimension for the same categories is 2, 4 and 9 kilometres respectively. For each port we then proceed with the creation of both buffers in order to be able to assess if the results are robust to different definition of ports' dimension. Once buffers were constructed, the second and final step was to calculate the mean luminosity of the underlying area.

Figure A1.7. Port of Beira, Mozambique, mean and maximum dimension buffer, 2003.



Dimension and luminosity of the port of Beira when the mean and maximum buffers are used.

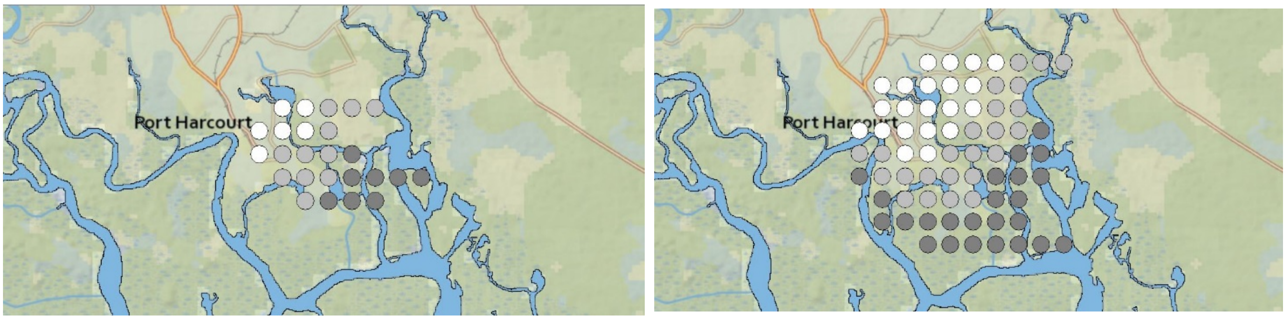


Figure A1.8. Port of Harcourt, Nigeria, mean and maximum dimension buffer, 2003.

Dimension and luminosity of the port of Port Harcourt when the mean and maximum buffers are used.

Figure A1.7 shows the buffered area around the ports of Beira, Mozambique when the mean and maximum port dimensions are used, while figure A1.8 presents the buffered area for the Port Harcourt, Nigeria, when the minimum and maximum dimensions are used. Table A1.2 reports instead the average luminosity for the three port categories using the two different buffers. As can be seen, the maximum buffer always yields a dimmer luminosity as it is more likely that zones which are not part of the port proper are included, but in both cases, there are clear indications of increased luminosity across the periods of consideration.

Table A1.2. Average luminosity for the three-dimension categories using the two buffers, 2003-2013 and selected years.

	Luminosity, mean 2003-2013	2003	2008	2013
Small port, average buffer	28.9148	23.2083	27.6979	35.6563
Small port, maximum buffer	26.6848	21.1617	25.5569	33.0446
Medium port, average buffer	53.3083	48.94	53.6763	57.7188
Medium port, maximum buffer	45.893	40.2935	45.7828	51.1822
Large port, average buffer	49.1521	48.6161	49.3636	52.5308
Large port, maximum buffer	39.1516	37.8729	39.0169	42.1848

Summary statistics of DMSP OLS luminosity value for all ports included in the sample using the two different buffers, whole period and selected year.

Supplementary Tables and Figures

Table A2.1. Estimation of the Gravity Model between Cities and Ports

Multi-level	*(1) Travel Time*	*(2) Travel Distance*	*(3) Euclidian Distance*
Distance	-0.644***	-0.693***	-1.348***
	(0.175)	(0.160)	(0.184)
GDP cap OC	-0.545***	-0.541***	-0.302***
	(0.0700)	(0.0701)	(0.0555)
Population OC	0.203	0.202	0.254**
	(0.138)	(0.138)	(0.108)
GDP cap DC	-1.368***	-1.365***	-1.343***
	(0.0951)	(0.0951)	(0.0862)
Population DC	0.429***	0.423***	0.366***
	(0.142)	(0.142)	(0.127)
Border	-3.969***	-4.049***	-4.203***
	(0.506)	(0.508)	(0.452)
Language	5.240***	5.251***	4.815***
	(0.385)	(0.385)	(0.360)
Com. Colonizer	-5.545***	-5.541***	-5.150***
	(0.472)	(0.471)	(0.434)
FTA	2.124***	2.106***	1.516***
	(0.388)	(0.378)	(0.324)
Legal Set	-0.239	-0.254	-0.170
	(0.284)	(0.283)	(0.250)
Econ. Activity City	0.362***	0.362***	0.368***
	(0.0102)	(0.0102)	(0.00906)
Econ. Activity Port	0.467***	0.470***	0.142*
	(0.125)	(0.125)	(0.0863)
Observations	6,432	6,432	7,521

Note: estimation based on the World Bank Enterprise Survey, UN COMTRADE and CEPII data between 2004 and 2016. Model estimated using a multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is a measure of trade flow between each city-port given by the interaction between the size of each port, calculated as the overall size of port provided by the WPI data multiplied by the average size of cargo ships across time derived from the OECD-ITF report (2015), and the overall weighted import competition from all foreign countries for each city, calculated as above by the averaged share of each city in the country-industry total imports. Econ. Activity City is measured in terms of city total sales. Econ. Activity Port is measured by the average luminosity across time.

Table A2.2. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: Multi-level regression with firm fixed-effects

Multi-level	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	0.0449***	0.0148***	-0.0353**	0.0893***
	(0.0171)	(0.00429)	(0.0150)	(0.0118)
SALES	1.007***	-0.0212**		0.544***
	(0.0128)	(0.00861)		(0.0139)
EMPL	-0.683***	-0.0331***	0.789***	
	(0.0258)	(0.0104)	(0.0193)	
WAGE	-0.142***	0.00211	0.252***	-0.169***
	(0.0150)	(0.00487)	(0.0120)	(0.0102)
AGE	0.00111	0.00490	0.000659	0.199***
	(0.0328)	(0.0112)	(0.0290)	(0.0248)
EXP	-0.0834	-0.00178	0.163***	0.322***
	(0.0581)	(0.0196)	(0.0508)	(0.0426)
K_EXP	-0.0237***	-0.000724	0.0222***	0.00345
	(0.00292)	(0.000981)	(0.00254)	(0.00215)
TFP		0.0162**	0.750***	-0.344***
		(0.00635)	(0.00959)	(0.0135)
Observations	1,957	1,957	1,957	1,957

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using a multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2.3. First stages of the IV Multi-level regressions with firm fixed-effects

IV First-Stage	*(1)*	*(2)*	*(3)*	*(4)*
	TFP	*SKILL*	*SALES*	*EMPL*
	IPW_CHN	*IPW_CHN*	*IPW_CHN*	*IPW_CHN*
PWD	4.997***	5.083***	5.116***	5.007***
	(1.815)	(1.852)	(1.855)	(1.860)
SALES	0.00341	-0.0213		0.0412**
	(0.0110)	(0.0255)		(0.0185)
EMPL	0.0813***	0.102***	0.0850***	
	(0.0225)	(0.0287)	(0.0207)	
WAGE	-0.0224*	-0.0217	-0.0268*	-0.0398***
	(0.0133)	(0.0151)	(0.0138)	(0.0143)
AGE	-0.0234	-0.0246	-0.0251	-0.00581
	(0.0302)	(0.0320)	(0.0319)	(0.0316)
EXP	-0.109**	-0.114**	-0.117**	-0.0835
	(0.0527)	(0.0556)	(0.0555)	(0.0550)
K_EXP	0.00135	0.00221	0.00172	0.00249
	(0.00267)	(0.00286)	(0.00280)	(0.00287)
TFP		0.0256	0.00951	-0.0151
		(0.0221)	(0.0108)	(0.0189)
Observations	1,945	1,945	1,945	1,945
F-Test	29.239	19.484	27.462	24.699
Anderson LM	28.695	18.396	27.025	24.408
Sargan	0.000	0.000	0.000	0.000

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using a multi-level regression with firm fixed effects. Standard errors reported in parentheses. The dependent variable is the city-industry level measure of Chinese imports competition. PWD is the instrumental variable measuring the ports water depth interacted with the average size of container ships and weighted by the gravity force between each city-port pairs. F, Anderson LM and Sargan tests for the exogeneity and validity of the instrument are reported. *** p<0.01, ** p<0.05, * p<0.1.

Table A2.4. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: OLS regression with firm fixed-effects

OLS	*(1)*	*(2)*	*(3)*	*(4)*
	TFP	*SKILL*	*SALES*	*EMPL*
IPW_CHN	0.0688**	0.0366**	-0.0245*	0.0342*
	(0.0325)	(0.0152)	(0.0143)	(0.0179)
SALES	1.183***	-0.0309		0.486***
	(0.0240)	(0.0202)		(0.0212)
EMPL	-0.994***	-0.0623**	0.887***	
	(0.0577)	(0.0255)	(0.0388)	
WAGE	-0.280***	0.0113	0.322***	-0.177***
	(0.0261)	(0.0105)	(0.0171)	(0.0140)
AGE	0.0525	0.0160	-0.0263	0.120***
	(0.0671)	(0.0259)	(0.0501)	(0.0368)
EXP	0.0211	0.00906	0.0218	0.215***
	(0.103)	(0.0391)	(0.0771)	(0.0565)
K_EXP	-0.0307***	-0.00252	0.0224***	-0.00201
	(0.00439)	(0.00167)	(0.00327)	(0.00250)
TFP		0.0283*	0.658***	-0.302***
		(0.0152)	(0.0134)	(0.0175)
Observations	2,105	2,105	2,105	2,105

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an OLS regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2.5. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: 2SLS regression with firm fixed-effects

2SLS	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	0.563***	0.402**	-0.0784**	0.256**
	(0.188)	(0.166)	(0.026)	(0.115)
SALES	1.156***	-0.0193		0.488***
	(0.0299)	(0.0302)		(0.0261)
EMPL	-1.011***	-0.111**	0.878***	
	(0.0703)	(0.0440)	(0.0424)	
WAGE	-0.309***	0.00113	0.330***	-0.190***
	(0.0349)	(0.0177)	(0.0207)	(0.0197)
AGE	0.119	0.0348	-0.0273	0.0811*
	(0.0859)	(0.0386)	(0.0561)	(0.0479)
EXP	0.213	0.0985	0.0215	0.111
	(0.148)	(0.0694)	(0.0972)	(0.0826)
K_EXP	-0.0372***	-0.00372	0.0255***	-0.000102
	(0.00552)	(0.00260)	(0.00363)	(0.00331)
TFP		0.0149	0.657***	-0.291***
		(0.0237)	(0.0151)	(0.0218)
Observations	2,105	2,105	2,105	2,105

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using a 2SLS regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2.6. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: IV Multi-level regression with firm fixed-effects using Ports Night Lights

IV Multi-level	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	1.168***	1.053***	-0.197*	8.522***
	(0.274)	(0.361)	(0.117)	(0.161)
SALES	1.061***	-0.0099		0.350***
	(0.0140)	(0.00812)		(0.0105)
EMPL	-0.859***	-0.0518***	0.965***	
	(0.0292)	(0.00910)	(0.0163)	
WAGE	-0.0775***	0.00985*	0.102***	0.0547***
	(0.0156)	(0.00562)	(0.0105)	(0.00619)
AGE	-0.0277	-0.00847	0.0427**	0.118***
	(0.0310)	(0.0125)	(0.0213)	(0.0117)
EXP	-0.0437	0.00346	0.126***	0.124***
	(0.0585)	(0.0225)	(0.0403)	(0.0219)
K_EXP	-0.0343***	-0.00105	0.0524***	-0.0175***
	(0.00275)	(0.00108)	(0.00191)	(0.00118)
TFP		-1.87e-05	0.794***	-0.376***
		(0.00349)	(0.00760)	(0.00800)
Observations	1,945	1,945	1,945	1,945

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2.7. Impact of Chinese imports competition on the performance of Sub-Saharan African firms: IV Multi-level regression with firm fixed-effects using only ports within 3 days of travel time.

IV Multi-level	*(1)* *TFP*	*(2)* *SKILL*	*(3)* *SALES*	*(4)* *EMPL*
IPW_CHN	1.366***	0.0655	-1.156***	0.987***
	(0.343)	(0.0523)	(0.275)	(0.202)
SALES	1.040***	-0.0199**		0.619***
	(0.0137)	(0.00778)		(0.0164)
EMPL	-0.620***	-0.0275***	0.721***	
	(0.0382)	(0.0106)	(0.0292)	
WAGE	-0.0296***	0.00640**	0.0793***	-0.0563***
	(0.0100)	(0.00313)	(0.00817)	(0.00731)
AGE	-0.0622*	0.00608	0.0666**	0.150***
	(0.0336)	(0.0114)	(0.0283)	(0.0244)
EXP	-0.206***	-0.00430	0.258***	0.277***
	(0.0684)	(0.0206)	(0.0582)	(0.0453)
K_EXP	-0.0275***	-0.000667	0.0262***	0.000599
	(0.00294)	(0.00101)	(0.00245)	(0.00219)
TFP		0.0160**	0.713***	-0.378***
		(0.00653)	(0.00991)	(0.0139)
Observations	1,945	1,945	1,945	1,945

Note: estimation based on the World Bank Enterprise Survey and the UN COMTRADE data between 2004 and 2016. Model estimated using an instrumental variable multi-level regression with firm fixed effects. Standard errors reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italia

Tel. +39 02.520.36934
Fax. +39.02.520.36946

E-mail: letter@feem.it
www.feem.it

FONDAZIONE ENI ENRICO MATTEI