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Quentin Hounyonou. Essay on Energy Access and Chinese Import Competition in Africa. Economics and Finance. Université Paris sciences et lettres, 2022. English. NNT : 2022UPSLM081 . tel-04121251

HAL Id: tel-04121251

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THÈSE DE DOCTORAT
DE L'UNIVERSITÉ PSL

Préparée à Mines Paris

Essay on energy access and Chinese import competition in Africa

Essai sur l'accès à l'énergie et la concurrence des importations chinoises en Afrique

Soutenue par

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Le 13 Décembre 2022

École doctorale n°543

**Sciences de la Décision,
des Organisations, de la
Société et de l'Échange
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Remerciements

Au terme de ces quatre années de recherche doctorale, je tiens à adresser mes sincères remerciements à mon encadrante, professeure Margaret Kyle, pour avoir accepté de m'encadrer et surtout de m'avoir renouvelé sa confiance au fil du temps. Je saisis donc ce canal pour lui témoigner toute ma gratitude car sans elle, cette thèse ne deviendrait guère une réalité. Ses orientations et ses conseils ont été d'une portée incommensurable. Malgré l'écart linguistique, son dévouement au travail et son ambition de réussir sa mission l'ont obligée à surmonter cette barrière dans nos discussions. A côté d'elle, se trouve le professeur Ahmed Tritah, mon co-encadrant. Humble, polyvalent, astucieux, dévoué et surtout très flexible, il a été à mes côtés du début de cette thèse jusqu'à la fin tant dans la vie sociale mais surtout dans les études. Il a su jouer un rôle de facilitateur qui a abouti à l'accomplissement de ce projet. Son assistance indéfectible se lit à travers la diversité dont fait montre le contenu de cette thèse. Malgré son calendrier chargé car étant sur plusieurs fronts, il ne ménage aucun effort à répondre présent quand il le faut. C'est l'opportunité pour moi de lui dire un spécial merci car j'ai beaucoup appris à ses côtés sur plusieurs plans.

Tel un père de famille, l'immense rôle fédérateur du professeur Pierre-Noel Giraud est sans comparaison. Pièce maîtresse et véritable chef d'orchestre de la chaire Economie Industrielle de l'Emergence de l'Afrique (EIEA), M. Giraud a un sens d'écoute et d'humilité irréprochable qui a d'ailleurs permis l'effectivité de cette thèse malgré mes multiples défauts. En dehors de ces interventions indispensables auprès de l'Université Mohamed VI Polytechnique (UM6P) pour pallier les besoins fondamentaux de la chaire, M. Giraud porte de temps en temps un regard critique sur les différents sujets traités par les doctorants de la chaire. Ce faisant il apporte son avis quand il le faut sur certaines thématiques et n'hésite pas à orienter vers des sources utiles quand il le faut. C'est l'occasion de lui témoigner toute ma reconnaissance pour ses conseils et orientations.

A l'UM6P et à l'Office Chérifin du Phosphate (OCP), je vous envoie un merci retentissant car cette thèse n'aurait pas été possible sans le financement que vous m'avez apporté. Au docteur Jamal Azizi, directeur de la chaire EIEA, je lui témoigne toute ma reconnaissance pour l'effort qu'il a déployé durant ce long parcours pour satisfaire mes besoins administratifs auprès de l'UM6P.

Un grand merci à la Chaire *Energie et Prospérité* (Institut Louis Bachelier) pour ses différents séminaires qui m'ont été d'une grande utilité mais surtout pour son accompagnement financier lors de ma participation à diverses conférences.

Les commentaires du professeur Saïd Hanchane sur mes papiers de recherche ont été d'une importance très capitale et c'est l'occasion pour moi de lui dire un spécial merci. Mes pensées vont

également à l'endroit du professeur Pierre Fleckinger pour son assistance et sa sympathie à mon égard depuis le début de cette thèse et au professeur Mathieu Glachant, directeur du laboratoire Cerna, merci à vous, toutes les fois que vous avez échangé avec moi sur mes sujets. Permettez-moi de vous signaler que ces discussions ont laissé des traces positives dans le document. A tous les autres chercheurs du Cerna (Sven, Dennis, ...), veuillez recevoir ma profonde gratitude pour toutes vos contributions directes ou indirectes à travers les séminaires qui nous réunissaient de temps en temps.

Mon passage à l'Organisation Mondiale du Commerce (OMC) m'a permis de rencontrer des personnes formidables. Je profite de cette aubaine pour témoigner toute ma reconnaissance à Monsieur José-Antonio Monteiro, mon mentor dans ladite institution qui n'a ménagé aucun effort à passer au peigne fin toutes les lignes de la thèse avec des commentaires pertinents. D'une manière analogue, mes remerciements vont à l'endroit de Monsieur Kimm Sèna Gnanon, pour le temps accordé pour décortiquer le document et surtout pour ses conseils et orientations.

C'est le moment de dire merci à tous les doctorants du Cerna en l'occurrence ceux de la chaire EIEA, pour tous ces moments passés ensemble et surtout les échanges fructueux, parfois houleux, que nous avons lors de nos séminaires ou en petits groupes. Houleux mais utiles! Autant que vous êtes, je vous aime, Maghrébins comme Subsahariens sans oublier les Français et Autres.

Je me permets de saisir cette opportunité pour remercier Dr Johanna Choumert-Nkolo et Dr Mathilde Maurel qui ont accepté d'être rapporteuses de cette thèse. C'est tout un plaisir pour moi de recevoir vos remarques et suggestions qui me seront à coup sûr très utiles au vu de vos expériences dans la recherche.

Cette longue liste de témoignages ne saurait prendre fin sans remercier Mme Barbara Tous-saint, qui dans l'ombre accomplit au quotidien une mission nécessaire pour le bon déroulement de cette thèse. De même, à toutes les personnes qui de près ou de loin m'ont encouragé à aller de l'avant et à être résilient face aux péripéties, recevez ma profonde gratitude. Un spécial merci à ma famille en particulier à mon père Hounyonou Kponou Victor et à ma mère Hodonou Justine, pour qui je dois un grand merci pour m'avoir assisté, sans faille, moralement et financièrement. Veuillez recevoir l'honneur qui vous est dû!

Résumé

Les pays africains aspirent à un développement industriel pour diversifier leurs exportations, actuellement concentrées en ressources naturelles. Cependant, l'électrification et le renforcement de la compétitivité des entreprises nationales restent un défi lorsqu'elles font face à la concurrence des importations, notamment celle chinoise. Ce sujet est au cœur de la présente thèse, divisée en trois chapitres. Le premier analyse l'impact de l'accès des ménages tanzaniens à l'électricité sur leur consommation et leurs revenus issus des activités domestiques. Les résultats suggèrent que l'accès à l'électricité entraîne une augmentation de la consommation quotidienne des ménages. De même, le chiffre d'affaires et le nombre d'emplois créés sont plus élevés dans les activités à forte intensité capitaliste favorisées par l'électricité. Dans le deuxième chapitre consacré à l'effet du commerce sino-africain sur la croissance des entreprises africaines, les résultats empiriques (RE) suggèrent que la pénétration de la Chine (PC) réduit la croissance des petites et jeunes entreprises, tandis que les grosses entreprises ont connu un effet pro-concurrentiel. Les entreprises exportatrices ont été doublement affectées, car leur croissance a baissé lorsque la PC a augmenté sur le marché extérieur commun. Enfin, le troisième chapitre a étudié comment la PC sur les marchés africains a affecté la performance des entreprises (PE). D'un point de vue théorique, la productivité (PTF) et l'intensité énergétique (IE) des entreprises sont inversement liées, tandis qu'il existe une relation logarithmique entre ces indicateurs et le niveau de production des entreprises. Les RE montrent que la PC sur le marché africain a entraîné une baisse de la PTF et de l'IE des petites et moyennes entreprises sans impact significatif sur les grosses entreprises. Sur la base des résultats théoriques, nous déduisons que la diminution de l'IE pourrait s'expliquer par la réduction du niveau de production. Alors que les obstacles électriques et financiers affectent négativement la PE, les petites entreprises confrontées aux obstacles électriques et les grandes entreprises confrontées aux obstacles financiers ont amélioré leurs performances sous l'impulsion de la compétition chinoise. Les RE ont également révélé que la PTF affecte négativement l'IE, sans qu'il y ait de causalité inverse.

Mots clés : Energie, ménage, consommation, commerce Chine-Afrique, Entreprise, Productivité, Développement financier

Abstract

African countries aspire to industrial development to diversify their exports, currently concentrated on natural resources. However, the electrification and the reinforcement of the competitiveness of national companies remain a challenge when companies face fierce import competition, including from Chinese products. This topic is at the heart of the present thesis, which is divided into three chapters. The first chapter analyses the impact of Tanzanian households' access to electricity on their consumption and income from home-based activities. The findings suggest that electricity access leads to an increase in households' day-to-day consumption. Likewise, turnover and the number of jobs created have resulted in capital-intensive businesses, but electricity is essential to be capital-intensive. In the second chapter dedicated to the effect of Sino-African trade on African firms' growth, the empirical evidence suggests that China's penetration reduces the growth of small and younger firms, while larger firms have experienced a pro-competitive effect. Exporting firms were hit twice, as their growth decreased when China's penetration increased in the common external market. Finally, the third chapter investigates how China's penetration into African markets has affected firms' performance. From the theoretical perspective, firms' productivity and energy intensity are inversely related, while there is a logarithmic relationship between these indicators and firm production level. Empirical results show that China's penetration into the African market has led to a decrease in both productivity and energy intensity of small and medium firms, but has exerted no significant impact on large firms. Based on the theoretical results, we deduce that the decrease in energy intensity could be explained by the reduction of the production level. While both electricity and financial obstacles affect negatively firms' performance, small firms facing electricity barriers and large firms facing financial barriers have improved their performance under the impulse of the Chinese competition. Empirical results have also revealed that productivity negatively affects energy intensity, while there is no reverse causality.

Keywords : Energy, Household, Consumption, China-African trade, Firm, Productivity, Financial development

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Chapitre 1

General Introduction

In economics, an important indicator of the population's well-being is the consumption of goods and services made by the public and private sectors (e.g., [Moratti, 2012]). Access to energy is essential for the production of these goods and services (e.g., [SDG, 2021]), and hence influences populations' welfare. However, the situation regarding energy access in Africa in particular in the Sub-Saharan area is dramatic. According to SDG (2021), among the 733 million (in 2020) people without access to electricity in the World, 77% live in sub-Saharan Africa (Figure 1.1).

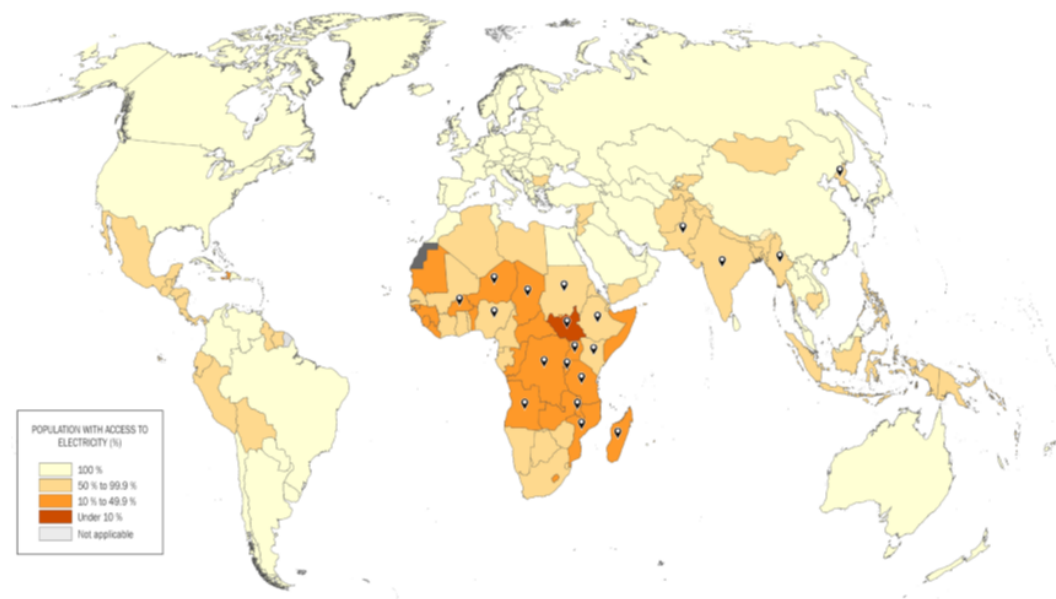


FIGURE 1.1 – Share of population with access to electricity in 2020 (source : World Bank 2022)

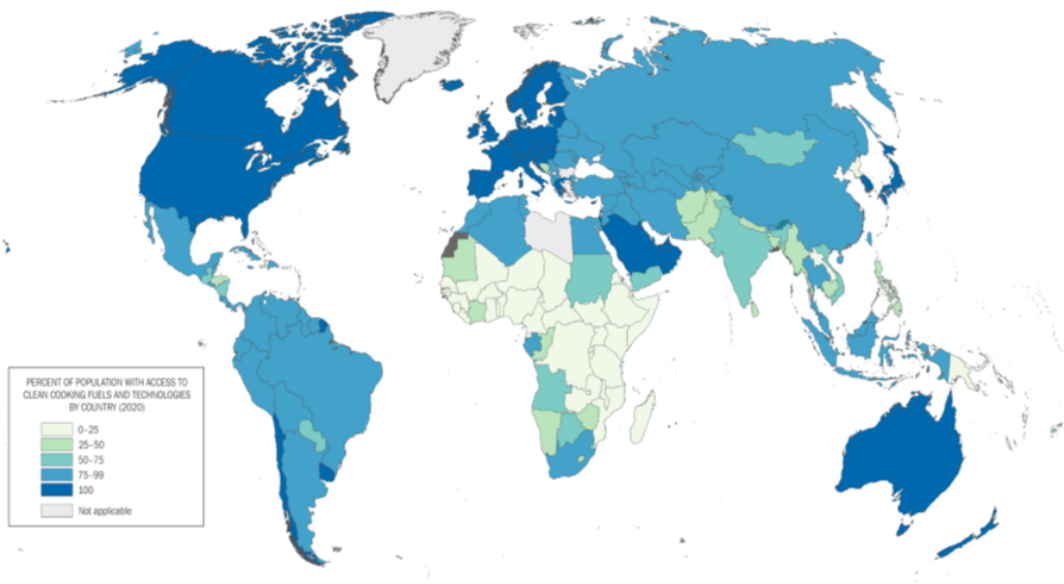


FIGURE 1.2 – Share of population with access to clean cooking fuels and technologies, by country, 2020 (source : World Bank 2022)

The situation is even worse when we consider cooking energy (Figure 1.2). The report pointed out that access to clean cooking energy is a major concern in developing countries, especially in African ones. Around 31 percent (2.4 billion (2.1–2.7) people) are still cooking primarily with polluting fuels and technologies, such as charcoal, coal, crop waste, dung, kerosene, and wood. The majority of households that lack access to electricity and clean cooking energy are concentrated in rural areas. According to [SDG, 2021], in 2020, around 80 percent of the world’s people without access to electricity live in rural areas, with 75% being located in Sub-Saharan Africa. As for clean cooking fuel, in 2020, 86 percent of people in urban areas had access to clean fuels and technologies compared with only 48 percent in rural populations. While the seventh Sustainable Development Goal (SDG7) aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030, Sub-Sahara Africa is far from achieving this goal. This is also the case for all other SDGs, as shown in Figure 1.3 where Africa is ranked at the last position based on the SDG’s index ([Sachs, 2022]). The figure also reveals that Africa is the great beneficiary of the accomplished effort by the rest of the world mainly the developed countries to target the SDGs. Africa’s performance in terms of the attainment of SDGs is not surprising. Indeed, there is a strong correlation between SDG7 and other SDGs. The literature has considered the socio-economic impacts of the lack of energy access, as well as the channels through which these impacts operate at the macro and micro levels. The lack of access to electricity or affordable electricity may constitute a huge impediment to African industrialization that is necessary to bring out millions of African people from unemployment and poverty ([Rud, 2012], [Anning, 2018]). For instance, less electrified countries attract less foreign direct investment flows ([Inglese-Lotz, 2021], [Chandio, 2020]) while the latter represents an important lever for easing social and economic tensions ([Sinkala, 2014], [Brincikova, 2014],

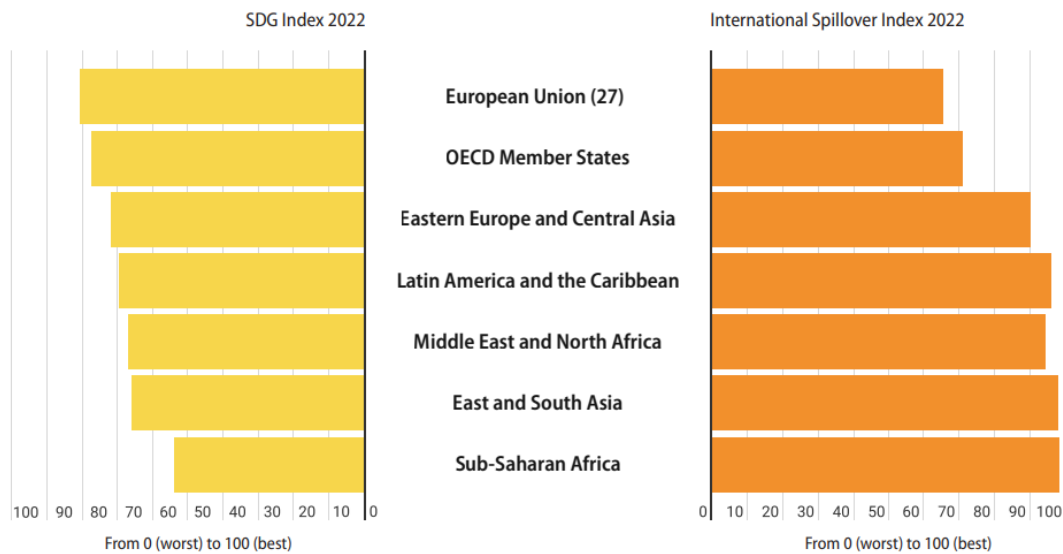


FIGURE 1.3 – SDG Index score vs International Spillover Index score (source : World Bank 2022)

[Abor, 2008], [Klein, 2001], [Gohou, 2012]). The health and education sectors are also among the most impacted. Due to the absence of electricity, rural areas suffer from a strong deficiency in health and education infrastructures that explains the low expectancy life and the literacy rate of the rural population ([Kanagawa, 2008], [Olanrele, 2020], [Nadimi, 2018], [Bridge, 2016], [Sarkodie, 2020]). At the microeconomic level, households that have access to electricity create income-generating activities (IGA) that improve their revenue. Electricity also offers a good condition for girls in electrified households to improve productivity in household tasks ([Peters, 2009]). Another advantage is the fact that the electric light creates a good environment for pupils to work at night and allow them to use the work tools like computer, laptops, and phone ([Arraiz, 2015]). However, as clearly stated in SDG7, the affordability, and reliability of electricity are also important and need to be taken into account in any analysis. According to the Energy Sector Management Assistance Program (ESMAP-2015), access to energy is not just a simple binary variable, but rather a multi-level variable. The simplistic questions in the old surveys do not consider other dimensions of energy access,¹ such as the use of multiple fuels and devices, varying levels of access and use, the quality and safety of the energy source, the affordability of consumer electricity service, and the importance of other household energy services such as space heating and lighting. This information is relevant in the case of Africa characterized by poor electricity infrastructure. Furthermore, the generation of electricity and the transport sector are

1. Household electricity : Questions on the main source of electricity, appliances powered, hours of electricity available each day and each evening, and frequency and duration of unscheduled blackouts [SDG, 2021]

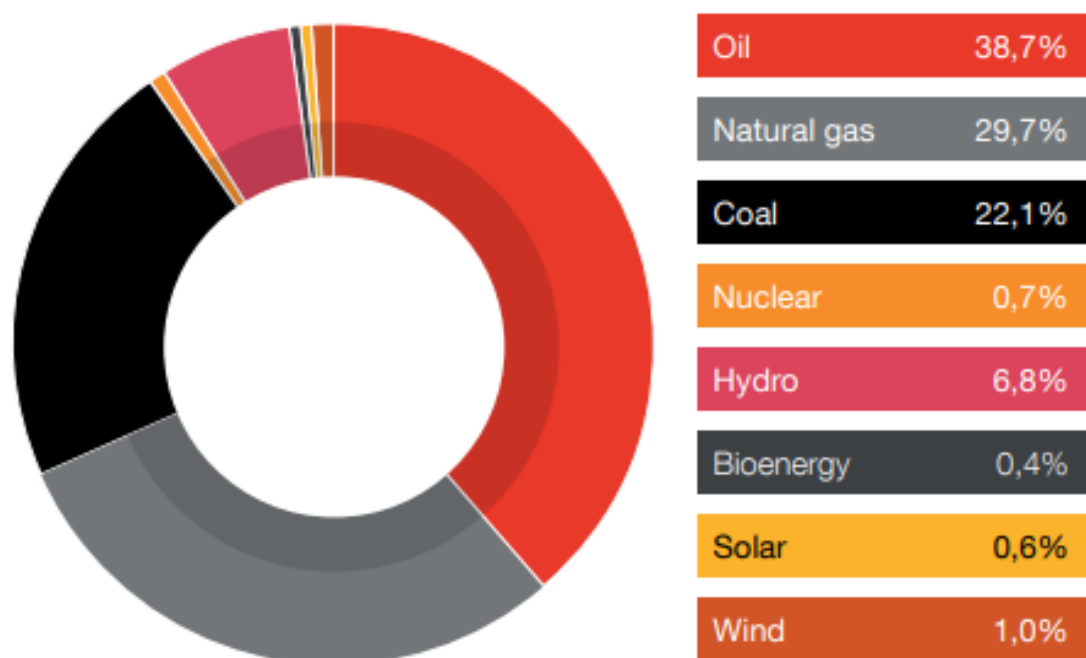


FIGURE 1.4 – Africa’s current energy generation mix (source : BP Energy Outlook 2020)

still dominated by fossil fuels. According to Africa Energy Review (2021),² non-renewable energies represent around 90% of the energy mix in 2020 (figure 1.4). This explains the high volume of the main gas of the greenhouse effect (that is CO_2) in the atmosphere, causing climate change and heart diseases ([Dennekamp, 2010], [Bernard, 2001]). Finally, fossil fuels that are used for cooking, generate also particles (including CO_2) that are seriously harmful to health.

Household welfare is not only dependent on the goods and services produced by local industries but also on imported ones. However, these imports can constitute an opportunity or threat to the local industries’ growth. The successive waves of trade liberalization, from the creation of the General Agreement on Tariffs and Trade (GATT) in 1947 to that of the World Trade Organization (WTO) in 1995, have dominated the international economy literature. China’s accession to the WTO, at the end of 2001, is a case in point. As shown in Figure 1.5, China’s trade with the rest of the world has increased in an unpredictable way both with developed and developing countries, including Africa. The Sino-African trade can be considered the second wave of trade liberalization for almost all African countries. Indeed, not only the trade volume has increased but there has also been a strong diversification of products exchanged, including at extensive margins (that is, with the introduction of varieties of products, with different qualities). This penetration of Chinese products into the African markets is not without consequences for African economies, both at macro and microeconomic levels. At the macroeconomic level, the penetration of Chinese products into the African markets has resulted in the creation of many enterprises mainly services-oriented enterprises engaged in trade activities (e.g., [Sieber-Gasser, 2010]). African Manufacturing enterprises can also have access to cheap Chinese products, such as physical capital and intermediate inputs, that allow them to reduce their production costs.

2. <https://www.pwc.co.za/en/assets/pdf/africa-energy-review-2021.pdf>

African Exporting manufacturing firms are able to increase their market power both in the domestic and foreign markets.

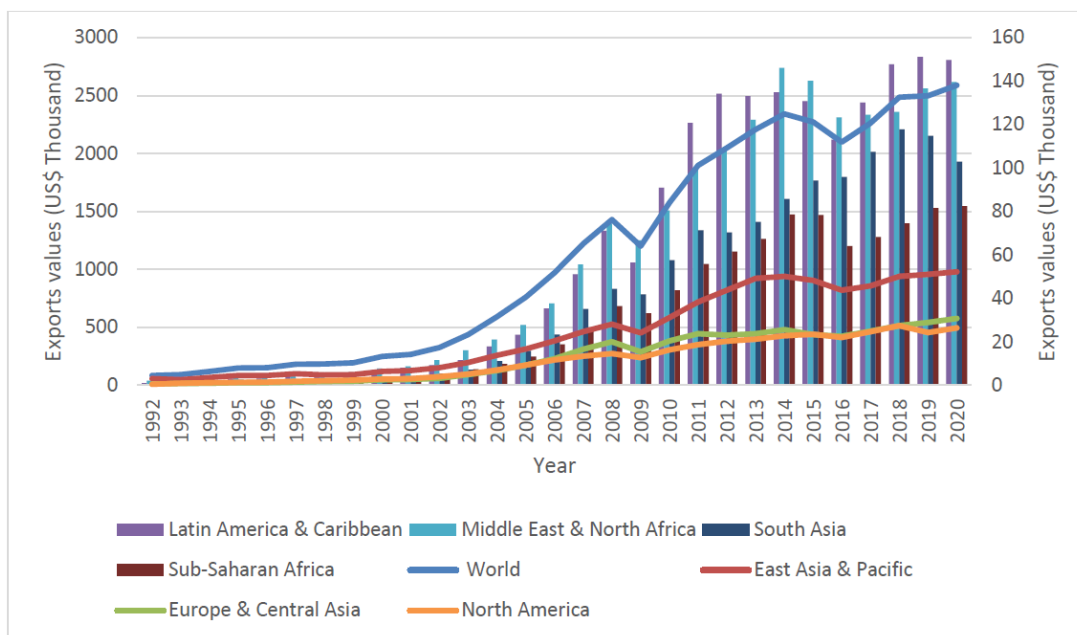


FIGURE 1.5 – China’s export in the world market by region (source : Own elaboration [Data from *World Integrated Trade Solution*])

Note : The second axis is for the bar chat.

We also notice from the literature that it is not only Chinese products that penetrate the African market but also Chinese Foreign Direct Investment (FDI). Chinese FDI flows can contribute to improving the gross domestic product (GDP), economic growth, as well as fiscal revenue that is necessary to reduce the burden of public debt in African countries (e.g., [Hosein, 2015], [Johnson, 2006], [Agyapong, 2019]). The Chinese FDI flows to Africa can also create employment, and reduce poverty (e.g., [Sinkala, 2014], [Boakye-Gyasi, 2015], [Onjala, 2008]). Meanwhile, the penetration of China into the African markets may result in greater competition in the domestic markets of African countries, it can also threaten domestic firms’ growth, and eventually hinder the industrialization of African economies. At the microeconomic level, Chinese products’ penetration into African markets represents a huge opportunity for African households to have access to cheaper products, such as household appliances, mobile phones, computers, and laptops. The low prices of Chinese products allow households to improve their purchasing power, increase their consumption as well as savings, and ultimately contribute to the improvement of African countries’ macroeconomic performance.

The above description, thus far, sheds light on the potential of trade with China, and energy access to significantly affect African economies. The present thesis focuses on these two factors by analyzing their microeconomic impacts on African countries. It includes three main chapters. Chapter (2) analyses the impact of electricity access on household consumption and home-based activity by focusing on Tanzanian households. Chapter (3) focuses on the effect of China’s penetration into African markets domestic on firms’ growth. Finally, chapter (4) explores whether

the penetration of China into African markets provides incentives to African firms to improve their productivity and energy efficiency under financial and electricity constraints.

According to the East Africa Economic outlook (2019), Tanzania was the third fastest economy (in terms of economic growth) in East Africa, preceded by Ethiopia and Rwanda. With an area of 947,300 km^2 ,³ the country counts about 61,498,438 people.⁴ About one-third of the population lives under the poverty line and almost 70% live on less than \$1.25 a day.⁵ The segments of people without access to electricity and clean energy cooking represent 39.9% and 5%, respectively with a strong disparity between rural and urban areas. Tanzania is endowed with several energy sources but less exploited. To increase the electrification rate in order to reduce the poverty and unemployment rates and accelerate the economic development of the country, a vast electrification program was launched by the government in collaboration with the Millennium Challenge Corporation over the period from 2008 to 2013. Several findings have emerged from the analysis on socio-economic impact analysis of this program ([Chaplin, 2017]). For example, there is an increase in children's hours of studying at night, ownership of electric appliances, time spent watching television, income, and a reduction of poverty measured by per capita consumption. There is also an increase in the likelihood to operate in IGA but not among low-cost-connection households. We have deepened this analysis by performing a similar analysis, focusing not only on the impact of electricity on household consumption (per adult equivalent) but also on IGA. The panel data (2008-2013) allowed us to compare the household situation before and after electrification. Based on the instrumental variable estimator and difference-in-difference method combined with the propensity matching score approach, we find that households' consumption increases significantly after they are connected to the electric grid. Concerning the IGAs, the analysis combined with various approaches (triple stage least square, instrumental Probit model, instrumental Tobit model, and endogenous switching regression model), and reveal that connected households' capital stock endowment represents the main channel through which electricity affects home-based activity (i.e. IGAs). This materializes through higher turnover and workers. The fact that electric light can prolong the daily working duration of IGAs is not enough to sustain their growth. We deduce that to be efficient, the electrification program should be accompanied by financial inclusion program that would enable households to equip their business. However, China's penetration into the African market would also be an opportunity for African firms to import cheaper goods and services.

While China's penetration is an opportunity for the informal sector it could constitute both an opportunity and an obstacle for the formal sector mainly the manufacturing one. Chapter (3) dedicated to China-Africa trade seeks to underline the effects of China's penetration into African markets on African manufacturing firms' growth. The impact of China's economic rise has led several researchers to undertake different analyses at the country level but also at the industry and firm levels. For instance, at the macroeconomic level, the variables of analysis are *economic growth* ([Miao, 2020], [Borojo, 2016], [Xin, 2014], [Lu, 2018]), *poverty rate* ([Jenkins, 2005], [Kaplinsky, 2007]), and *unemployment* ([Pigato, 2015], [Ebenstein, 2015]). At the microeconomic

3. <https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=TZ>

4. <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=TZ>

5. Bertelsmann Stiftung's Transformation Index (BTI) 2022.

level, the industries or firms' performance, measured by sales and labor growth ([Autor, 2013], [Malgouyres, 2017]) on the one hand, and the total factor productivity ([Bloom, 2016], [Darko, 2021]) on the other hand, has been at the heart of analysis. Analyses have been performed on upstream and downstream of firms (or industries) as well as on third markets. These studies have also sought to examine the impact of imports of China's inputs, and China's output on firm performance, as well as the competition effect on the common external market (CES). The studies have found mixed effects. Some studies found that China's competition in the domestic market is harmful to firms' performance, while others concluded the existence of a pro-competitive effect. This divergence in outcomes can also be observed at the input level. Concerning the effects of the third market, there is almost unanimity that China's competition in CES is a major threat to exporting firms. However, there are few studies on Africa. Chapter (3) aims to complement the existing literature by showing how China's imports can affect African firms upstream and downstream as well as in third markets by distinguishing between developing and developed markets. That is, on the one hand, we analyze China's input and output penetration impact on African firms' growth approximated by sales growth and labor growth. On the other hand, we consider the effect of China's penetration into the foreign common market on the exporting firms' growth. We find that China's output penetration into African markets represents a huge threat to small and younger⁶ firms, while it generates a pro-competitive effect for large firms. In the foreign common market, the increase in China's penetration into the African markets has led to a decrease in the exporting firms' growth, but the impact appears to be more pronounced in developed markets. While we expected China's inputs to have generated economies of scale and boosted African firms' growth, we find, that they affected negatively and significantly the firms' growth. We attribute this negative outcome to the fact that China's inputs might not be appropriate for African firms' working conditions, although the results may also be explained by the approach used to construct the indicator of inputs' penetration.

As shown in Figure 1.6, unreliable electricity supply and hindered access to the financial market represent the main obstacles faced by manufacturing firms in African countries mainly small and medium enterprises ([African Economic Outlook, 2019]). The results found in Chapter 2 (concerning small and younger firms) can become worse for firms that are confronted with these challenges. For instance, firms that face major obstacles in the financial market, would not be able to make the necessary investments to improve their efficiency so as to retaliate when facing an increase in imports from China. Likewise, firms confronted with bad-quality of electricity would be more vulnerable to China's penetration into the domestic market and would lose more in energy productivity if actions were not taken to improve it. Chapter (4) investigates not only the overall impact of China's imports on firms' performance i.e. total factor productivity (TFP) and energy efficiency approximated by the energy intensity (measured by the ratio of energy consumed to the value of output produced). It also seeks to investigate how African firms have managed to adapt to China's competition, despite their electricity and financial challenges. Finally, the chapter explores the direction of causality between the two indicators of the firms' performance,

6. Firms that are at most five years old

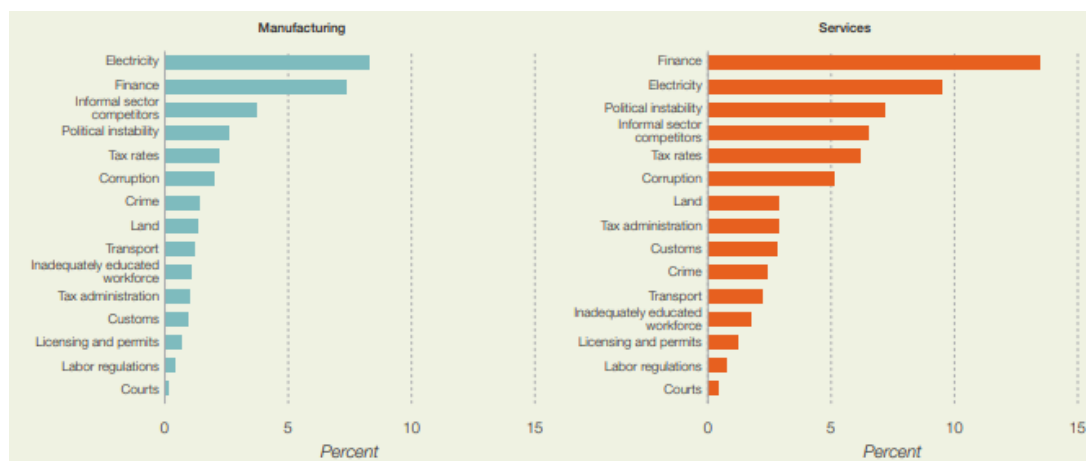


FIGURE 1.6 – Biggest obstacles to doing business in Africa, by firm size and sector, most recent year available during 2006–17 (source : AfDBG/AEO,2019)

Note : All values are survey-weighted.

namely productivity and energy intensity. There is a vast literature on the relationship between trade openness and productivity on the one hand, and between trade openness and energy efficiency, on the other hand. According to the former, competition from foreign countries following trade liberalization can be detrimental to domestic firms since the foreign goods can oust the domestic ones, leading to losses of economies of scale and firms' performance ([De Loecker, 2014], [Melitz, 2003]). However, there can also be an opportunity for dormant domestic enterprises to make use of all their potential ([Mukherjee, 2017], [Umoh, 2013]). In this case, China's imports can have a pro-competitive effect on firms' performance ([Melitz, 2003], [Darko, 2021]). The penetration of China's inputs is another channel through which China-Africa trade can enhance African firms' performance. As noted above, China can sell machines, appliances, and all other equipment goods as well as intermediaries inputs and energy-saving technologies relevant to the African manufacturing firms' activities ([Borojo, 2016], [Munemo, 2013]). Many studies have addressed this issue but not much in the context of China-Africa trade, which is the main contribution of this paper to the literature. Another contribution of this paper to the literature is the theoretical description of the relationship between firms' productivity, firms' energy intensity, and production level. This theoretical analysis is useful for the interpretation of empirical results, and the understanding of how China's penetration into African markets can affect firms' performance through its effect on their sales. The empirical outcomes based on the instrumental variables approach (two-stage least squares and three-stage least squares) have shown that China's penetration into the African market has led to a decrease in both firms' productivity and energy intensity of small and medium enterprises. But, according to the theoretical model, the reduction of energy intensity could be explained by the decrease in the firm's production level that leads to the decrease in energy use. However, overall, the improvement in productivity leads to a decrease in energy intensity but there is no reverse causality. Furthermore, among small firms, only those facing a shortage of electricity improve their productivity while among large firms, better performance is observed only for those facing financial obstacles. We conclude that China's penetration into the African markets has incentivized African firms to address their

challenges and develop their potential to stay in the market and continue to produce. We also deduce from our results that improving traditional performance (through higher productivity and energy efficiency) is not enough to compete with China, but firms should improve innovation at the product level to maintain their market share.

Chapitre 2

Electricity access, consumption, and home-based business : Evidence from Tanzanian households

Ce papier évalue l'impact de l'accès à l'électricité sur la consommation des ménages et les revenus des entreprises à domicile en Tanzanie. Il utilise des données de panel qui s'étendent de 2008 à 2013 et échelonnées en trois vagues. A l'aide des méthodes de différence première et de variable instrumentale, nous constatons que cet impact est positif et statistiquement significative avec une valeur avoisinant 120%. Nous utilisons ensuite la méthode des triples moindres carrés, le modèle probit instrumental et le modèle *Endogenous Switching Regression* pour montrer respectivement que l'électricité agit par le biais du stock de capital pour transformer les revenus des entreprises à domicile et leur permettre de créer des emplois.

1 Introduction

Energy, in all its forms, is important for human welfare and a healthy economy. It was a key factor in the first industrial revolution with the appearance of the steam engine that replaced human and animal labor [Wrigley, 2013]. Since then, labor productivity has increased, and the population's needs are covered faster than before. Today, energy exists in many forms including mechanical, thermal, chemical, and electrical, of which the last is the most useful. It is omnipresent in all human activities, and it is becoming necessary both at home and in companies. Because we can pass from one form of energy to another, electrical energy can be obtained from all other forms of energy. For the widespread use of electricity, primary sources such as fossil fuels are generally required. Unfortunately, despite an abundance of these primary resources, Africa suffers from a crucial lack of electricity.

According to World Bank statistics¹ (2014), about 38% of the sub-Saharan African population has access to electricity while the equivalent figure is 45% for the whole of Africa [Agency,

1. <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZG>

2014] and 85% worldwide. These statistics prove the scale of the challenge in this sector, especially in sub-Saharan African countries including Tanzania. In fact, Tanzania is one of the countries whose energy situation is paradoxical. It has large energy reserves, of which very few are exploited. Its hydroelectric power potential is estimated at 4,700 megawatts, of which about 15 percent is used, natural gas is estimated at nine billion barrels of oil, and finally, its solar radiation is estimated at 4 to 7 kWh/m²/d with a sunshine duration of 2,800 to 3,500 hours per year [Group, 2015]. Despite these performances, only 32.8% of Tanzanian households have access to electricity [Tanzania, 2017] with 16.9% in rural areas compared to 65.3% in urban areas. Given that the installation of large factories and enterprises is conditioned, among other things, by the availability of electricity ([Kanagawa, 2008]; [Avila,]), rural areas will have to continue, for a long time, to put up with the paucity of their infrastructure and the consequent economic poverty which gives rural households a poor standard of living. In addition to this macroeconomic effect of electrification on household welfare, the literature postulates other micro-level effects that are no less negligible but very mixed. This paper examines the causal link between households' access to electricity and their income on the one hand, and, on the other, investigates how electricity transforms the revenue of home-based enterprises, thus creating externalities for the neighborhood.

This paper makes several contributions. The study is one of the few dealing with such a problem in Tanzania using panel data, to which we have applied the approach of first difference with instrumental variables to determine the effect of electricity on household consumption. The "triple stage least square" estimator is used for the transmission channel while the instrumental Probit and endogenous switching regression models are employed to assess the externality of households' access to electricity.

Results of the first model show a statistically significant positive effect of electricity on day-to-day household consumption (food, communication, and transport). This increase may be due to a reallocation of household income or, according to the second model, to a growth in the income of their home-based enterprise which is only possible for households with sufficient physical capital stock. Results also show that these home-based businesses are able to create employment when they are well equipped with physical capital, but the latter is dependent upon the presence of electricity. Therefore, we deduce from our analysis that households' access to electricity indirectly impacts their income and that of neighboring households through physical capital.

This paper is structured into five sections. Section 1 presents the literature review. Section 2 presents the data and some descriptive statistics while section 3 presents the methodology. Sections 4 and 5 describe the results and robustness tests.

2 Literature review

The omnipresence of electricity is becoming more and more evident today. Advances in various technological fields make life very dependent on energy and more particularly on electrical energy. The scarcity of the latter in the less advanced countries (and especially those of sub-

Saharan Africa) has brought the question of its universal accessibility to the forefront. For example, universal access to electricity is one of the UN's priority Sustainable Development Goals (SDGs) and is also one of the major issues being addressed by the African Development Bank. To this end, several electrification projects are being implemented on the continent in order to boost its economy and provide its people with a better life. However, the literature is peppered with controversial results regarding the achievement of these expected social and economic objectives. This paper focuses on how access to electricity affects households' income, measured through their consumption.

Households' possession of electricity is not intrinsically dependent on their desire to have it. Apart from the accessibility of the area where the household is located [Tzempelikos, 2007], its demographic characteristics, its level of well-being as well as the average educational level of its members ([Behera, 2017]; [Choumert, 2018]) are also factors determining the choice of electricity use in households. Having electricity improves the lives of households in many ways. It can improve their health, their members' educational level, and their economic status.

Access to electricity has a considerable impact on household health ([Berne, 2000]; [Dherani, 2008]; [Samad, 2013]; [Harris, 2013]; [Grimm, 2016]; [Po, 2011]; [Van de Walle, 2017]). Households traditionally use fossil fuels whose combustion emits noxious gases. Women are therefore the main victims of this phenomenon because, according to tradition in Africa and indeed many other developing countries, they usually do the cooking. Young children are also subject to this problem since they are constantly with their mothers, while schoolchildren have to spend time close to kerosene lanterns in order to study after dark. Access to electricity can thus reduce lung disease and eye problems caused by the use of kerosene ([Aklin, 2015]; [Gurung, 2011]; [Brass, 2012]; [Grimm, 2016]). The use of fans to renew the air in dwellings and the use of refrigerators to conserve the quality of food and drink for many days are also beneficial from the health and economic viewpoints for electrified households ([Bastakoti, 2006]; [Khandker, 2013]; [Kooijman-van Dijk, 2012]). Television is also a non-negligible source of health improvement since household members can learn much about, and better understand how to avoid certain dangers. Periods of cold weather also show how lack of electricity can affect health, particularly for the most vulnerable (the elderly for example) and people allergic to the cold because they suffer from a particular disease that is exacerbated by the cold. [Chirakijja, 2019], following a study carried out in the United States, showed that, because of the high cost of domestic heating, the mortality rate accelerates during cold periods. Most of these deaths are caused by cardiovascular and respiratory diseases. Households' access to electricity is, therefore, necessary for better health.

Albeit with reservations, the literature on education also finds that households' access to electricity increases the literacy rate ([Dinkelman, 2011]; [Gurung, 2011]; [Sovacool, 2013]; [Kanagawa, 2008]) and allows members to spend more time studying since electric lamps provide comfortable learning conditions after dark [Aglina, 2016]. It encourages learners to do more research, read more, and use computers and other things that can help them to perform better at school ([Kanagawa, 2008]; [Arraiz, 2015]). As a result, they reach higher academic levels and get jobs that can change the household's standard of living. Furthermore, in developing countries,

about 83% of households do not have access to clean cooking fuel [Outlook, 2019], a percentage that is higher in rural areas where they rely on harvesting wood. Under these conditions, girls are not able to attend school since they are responsible for wood collection. When households get access to electricity, they can use electrical cooking appliances, or they manage their time better to allow girls to learn more ([Peters, 2009]; [Agoramoorthy, 2009]; [Moharil, 2009]). In the long term, this contributes to reducing socio-economic gender inequality [Grogan, 2013]. The ultimate consequence of education is that being literate can help people to adopt a hygienic lifestyle and take more control over their lives which can in turn be useful to society.

The literature’s main focus is on households’ economic situation. What happens to household incomes when they get electricity? Researchers have done considerable work on this issue without reaching a consensus. Some studies conclude that electrification has a positive impact on households’ income and leads to a reduction in their poverty ([Barnes, 2002], [Khandker, 2009], [Fan, 2005b]). Other studies find no significant impact ([Bensch, 2011], [Escobal, 2001]), while yet others find negative impacts on the income of poor households². It should be noted that controversy prevails, especially in rural areas where the conclusions are far from unanimous ([Khandker, 2012b], [Peters, 2009], [Mensah, 2014], [Bernard, 2010], [Khandker, 2009], [Khandker, 2012a]). According to the literature, electricity affects household income through several channels. The main one is income-generating activity (IGA). Many papers have shown that there is growth in IGA in newly-electrified areas, leading to a growth in the employment rate ([Bastakoti, 2006], [Kooijman-van Dijk, 2010]). Since it is possible to have an IGA without access to electricity, once households get electricity, they can shift from non-electrified IGA to electrified IGA or extend their working time after dark ([Cabraal, 2005]; [Mishra, 2016]).

Furthermore, improvements in health could favor people spending more time on IGA or other economic activities. Likewise, the improvement in educational performance would increase the probability of an individual getting a good job. These two aspects would bring more income to households and increase their medium- or long-term consumption of food and non-food goods such as modern sources of energy. The transition from traditional fuels to modern energy allows women to spend less time on domestic activities (collecting wood, cooking, etc.) and to undertake other, more lucrative, activities, thus increasing their employment rate and reducing gender inequality ([Dinkelman, 2011]; [Grogan, 2009]; [Bowlus, 2008]).

In Tanzania, very few authors have shown an interest in the question of how electrification impacts household income. Among these papers, [Fan, 2005a] state that not only does the electrification of households have a significant and positive impact on their income, but a 1% increase in the number of connected households would lift some 140,000 people out of poverty. However, this work is not exclusively devoted to electricity but to all state infrastructure expenditures (education, health, roads, electricity, agriculture), the (binary) variable “access to electricity” has not been dealt with carefully since the connection of a household to the grid depends on several of the above-mentioned factors and is therefore endogenous. Consequently, the authors’ conclusion may be questioned since the coefficient of this variable could be biased and inconsistent. [Chaplin, 2017] apply a DID approach to evaluate the effect of an extension

2. <https://www.adb.org/documents/adb-annual-report-2005>

of the electricity grid on the welfare of newly connected households and also on (low-income) households that received a government subsidy. First, they find that the grid extensions had no clear impact on the number of hours children studied at night and whether the household operated any income-generating activity (IGA) while there is an increase in ownership of electrical appliances and operation of IGAs that use grid electricity. Likewise, low-cost-connection offers increased ownership of electrical appliances and worsened health outcomes, reduced poverty as measured by per capita consumption but had no clear impact on the likelihood of operating an IGA. However, being actually connected to the grid increased the number of hours children studied after dark, the likelihood of operating an electrified IGA, and income and reduce poverty. Other studies were also carried out in the country, but at the regional level, to evaluate the impact of access to electricity on the welfare of these communities. One example is Kigoma [Vohra, 2017] and [Hankinson, 2011].

The following diagram summarizes the three main channels through which electricity can affect household income according to the literature.

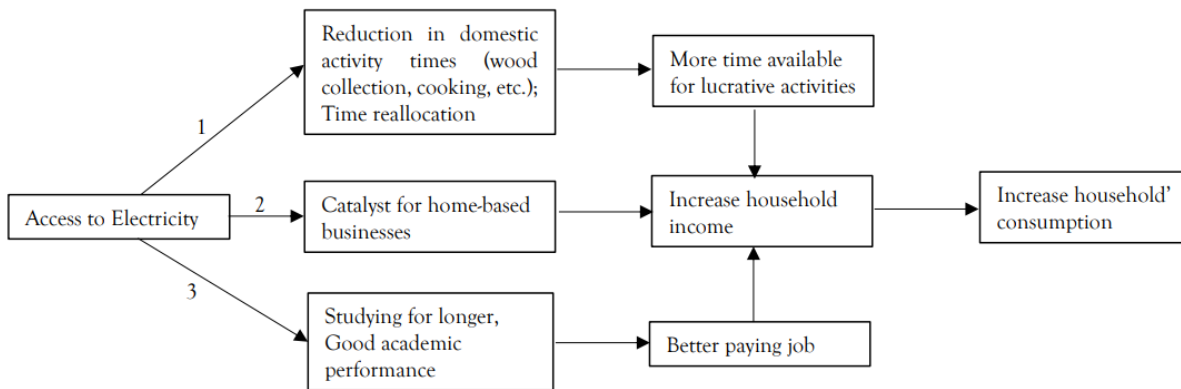


FIGURE 2.1 – Principal transmission channels (source : Own elaboration)

According to Channel 1, access to electricity not only allows women to better manage their time but also increases the productivity of hours allocated to domestic tasks. This creates a surplus of time for women to use for more lucrative purposes and increases household income. Channel 2 shows that access to electricity strengthens home-based businesses and increases their turnover. Finally, channel 3 is often expressed in the long term. It highlights the impact of access to electricity on education. Electricity offers better conditions for learning leading to the improvement of household members' skills. As a result, they are more likely to get a better-paying job, which in turn improves the household income in the long run.

3 Data and Descriptive Statistics

3.1 Data Sources

Since 2008, Tanzania has acquired a panel of data collected from a national survey, conducted in three phases at regular intervals of two years. Thus, the first phase started in October 2008 and

ended in October 2009 and included 3,265 households representing the national population in its geographical and ecological diversity. This base sample is divided into 409 enumeration areas across mainland Tanzania and Zanzibar. The sample makes it possible to extrapolate to Zanzibar and three zones in mainland Tanzania : rural areas, Dar es Salaam and other urban areas. In the next two phases, these households were monitored across space and time as far as possible to avoid attrition problems. Furthermore, individuals who left their initial households to create their own households were added to the survey data. This brings the sample size of the second phase to 3,924 and the third to 5,010 households respectively. The second phase was conducted from October 2010 to November 2011 and the third from October 2012 to November 2013. Individuals were also monitored. As a result, detailed data on health, education, consumption, crime, and other topics were collected at individual, household, and geographical (ward, district, regional) levels.

This survey was designed to meet three main objectives. The first is to monitor progress toward the goals set out in the National Strategy for Growth and Poverty Reduction. The survey provides annual high quality, twelve-month data relating to indicators that are representative at the national level and over time. This, therefore, acts as a key reference for monitoring a wide range of development indicators. The second objective is to provide a better understanding of the determinants of poverty in Tanzania and how it changes at the national level over time. It is also intended to serve as a basis for analyzing the determinants of income growth, changes in and improvement of academic performance, and changes in the quality of public service delivery. Finally, the survey aims at allowing rigorous evaluation of the impact of government and non-government development initiatives. To achieve this, the National Bureau of Statistics worked closely with relevant ministries to link administrative data on relevant projects to changes in development outcomes measured in the survey.

3.2 Descriptive statistics

3.2.1 household electricity sources

Here we give the statistics for Tanzania's main sources of electric power : generators, solar panels, and the Tanzanian electric energy production and distribution company (Tanesco). As shown in Table 2.1, the latter is the source used by most households, followed by solar panels in 2008 (used to a greater extent in rural areas) and generators in 2012.

TABLE 2.1 – Household electricity sources

Residence area	2008		2012	
	Rural	Urban	Rural	Urban
TanESCO	57	532	218	495
Community generator	15	13	2	0
Solar panels	13	2	66	12
Own generator	0	1	3	2
Total	85	548	289	509

Source : author's calculation

Given the small proportions of households using other sources, throughout the rest of the document we define as “electrified” only those connected to TanESCO.

The interest of our study is to capture the effect of access to electricity on household consumption and the channels through which this effect is transmitted. To this end, we distinguish two types of household : households initially without electricity in 2008 but which had it in 2012, denoted *treated households*, and the control group, consisting of households not connected between 2008 and 2012, denoted *untreated households*. Indeed, measuring the impact of electricity by comparing the “before and after” situations of *treated households* requires the counterfactual situation i.e. absence of electricity. As this is impossible to obtain, the control group provides an alternative. To be valid, it must have approximately the same characteristics as the *treated* group. Table 2.2 shows these two groups :

TABLE 2.2 – Control and treatment groups

Residence area	2008		2012	
	All	Treated	Control	Treated
Rural	1838	0	1786	52
Urban	511	0	394	117

Source : author's calculation

At the baseline date (2008), no household is treated i.e. no household has electricity. There are 1,838 in rural areas and 511 in urban areas. In 2012, 117 urban and only 52 rural households received the treatment i.e. were connected to TanESCO. This is in line with the national report (EASR 2016) on energy in Tanzania which reports a low rate of electrification of rural households. In total, we have 169 treated households and 2,180 untreated, most of which are in rural areas.

3.2.2 Variable of interest : household consumption expenditure

In Africa, it is difficult to collect information about household income, partly because of social considerations and also because most people work in the informal sector where incomes are very erratic. Household income is estimated either upward or downward, depending on the

survey/census conditions. If we assume that households do not consume more than they earn, the best way to approximate household income is to estimate their total actual expenditure [Datt, 1992]. However, this equivalence may be slightly wrong given that mutual aid and solidarity between households are still deeply rooted in African traditions. It is, therefore, possible for a household to consume or spend beyond its financial capacity. Its income can then drop without an accompanying drop in consumption. The sample being representative of the population, it would contain a low proportion of these types of households. Hence, consumption remains a powerful means of assessing households' income.

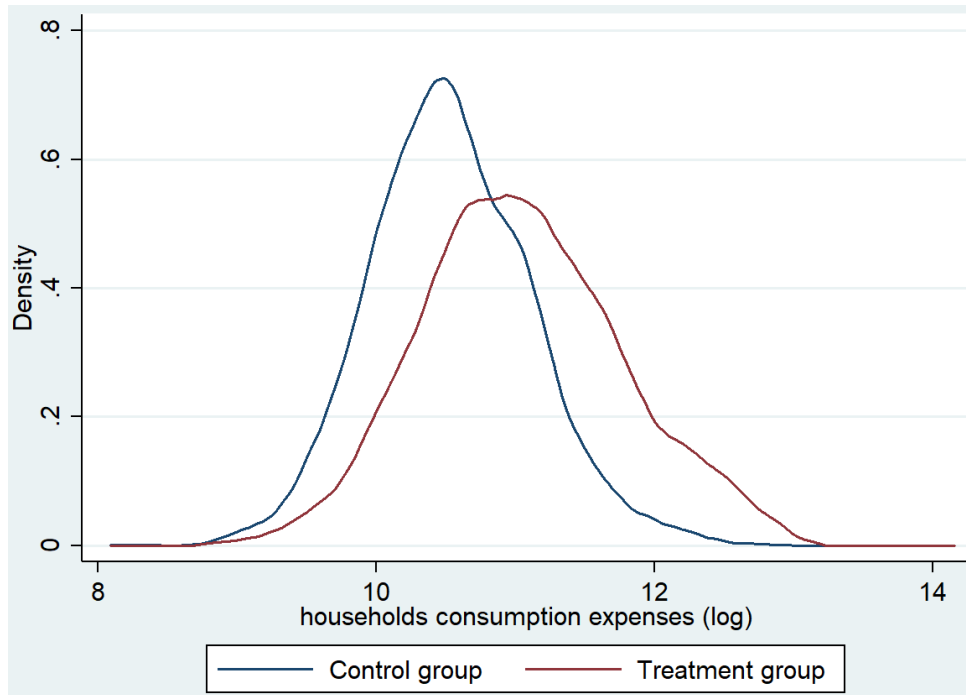


FIGURE 2.2 – Comparison of the total consumption expenses of each group (source : Own elaboration)

Figure 2.2 shows the distribution of household expenditure (in 2008) in the treatment and control groups. This is the total monthly expenditure per adult equivalent. We can see a shift of the red curve to the right. That means the treated households have, on average, a consumption, and therefore an income, higher than that of others. According to the literature ([Louw, 2008]; [Terza, 1986]; [Ziramba, 2008]) access to electricity bears a cost that can be an obstacle for low-income households. Apart from the unavailability of electrical energy in the household's immediate environment, its income level may also constitute an obstacle to its connection. As illustrated in Table 2.3, this assertion seems to be relevant due to the fact that the physical characteristics (roof, walls, floor) of households' dwellings show a big difference in favor of Treated households. The first column presents the characteristics of all households in the sample while columns (2) and (3) show those of the treated and untreated groups, respectively. Column (4) contains the coefficients of the linear regression of each characteristic on the variable T, which takes the value of 1 if the household is treated and the value of 0 otherwise. For each modality of a variable, a

significant coefficient means that the gap between the two groups of households is considerable. The table indicates that, unlike the “owner” households, there are more treated in the group of tenants. Proximity to a major road and to a market also favors treatment as well as living in flat, low-elevation areas. Finally, living in an urban setting also offers a greater opportunity to benefit from treatment.

TABLE 2.3 – Characteristics of treated and untreated households

		global sample <i>column 1</i>	Treated <i>column 2</i>	Untreated <i>column 3</i>	difference <i>column 4</i>
occupation	Owners	0.78	0.63	0.87	-0.24***
	Tenants	0.14	0.24	0.07	0.17***
walls	cement	0.44	0.73	0.29	0.43***
	Bamboo/mud	0.55	0.27	0.70	-0.42***
roof	sheet metal	0.62	0.93	0.49	0.44***
	Tile/concrete	0.02	0.02	0.00	0.01***
	Bamboo/other	0.37	0.05	0.50	-0.46***
floor	cement	0.42	0.85	0.23	0.62***
	earth	0.57	0.15	0.76	-0.61***
cooking fuel	gas	0.01	0.01	0.00	0.01***
	paraffin	0.03	0.05	0.01	0.04***
	coal	0.23	0.01	0.00	0.01***
	firewood	0.72	0.41	0.89	-0.48***
Middle of residence	urban	0.35	0.75	0.18	0.58***
Distance from major road	average(km)	17.88	13.10	20.58	-7.48***
Distance from near- rest market	average(km)	71.14	58.07	79.59	-21.52***
elevation	average(m)	705.15	492.87	824.14	-331.27***
slope	average(%)	4.97	4.14	5.47	-1.33***

Note : * pvalue<0.1; ** pvalue<0.05; *** pvalue<0.01

Source : author's calculation

One can therefore deduce that, in addition to income, other characteristics also prove the selective aspect that exists in the connection process of the two categories of households.

4 Methodology

4.1 Impact of electricity access on household consumption

As discussed above, there is a selection issue in the sample that would result from several factors. Some of these depend on households' intrinsic characteristics. However, the geographical and socio-economic characteristics of these households' location may also be an obstacle or an asset to their electrification. For instance, Table 2.3 reveals that treated households live in better housing and in more accessible geographical areas than untreated households. This selection issue in the reception of the treatment must be corrected in order to obtain consistent results.

While the location of development projects is often subject to conditions, the case of electrification is even more so. In the literature, very few papers ([Barron, 2014]; [Rud, 2012], [Grimm, 2016] [Torero, 2015]; [Barron, 2013]; [Barron, 2017]) have mentioned a random distribution of electrification projects at the national or community level. In the absence of random distribution, academics refer to more or less laborious tools to overcome the endogeneity issue. This is how [Bensch, 2011] and [Khandker, 2009] combined the propensity score matching (PSM) and difference-in-difference (DiD) method to ensure that the assessment of the treatment effect is performed on similar households and that the time-invariant unobservable factors likely to alter the treatment effect have been removed. The most widely-used method in the literature is that of an *instrumental variable* in a fixed-effects regression model. However, this instrumental variable is still not easy to find, and its nature depends not only on the available data but also on knowledge of the issue. In the specific case of electricity, geographical characteristics (slope, elevation, vegetation cover, etc.) and demographic characteristics (e.g. density) have been used as instruments in several papers ([Grogan, 2013], [Dinkelman, 2011], [Samad, 2013], [Lipscomb, 2013]). But these variables are inadequate in some cases, especially when dealing with economic variables such as income, consumption, and economic growth which are themselves related to geographical and demographic characteristics. In this case, it becomes difficult to correct the endogeneity issue relating to access to electricity. In response, several authors have decided to construct alternative instruments. This is the case of [Khandker, 2009] and [Van de Walle, 2017] who used the distance between the household and the nearest power line and the distance between the household and the nearest power station, respectively.

For a rigorous analysis, we also opt for the instrumental variable method. To assess the impact of electricity on household consumption, we follow [Dinkelman, 2011] :

$$y_{hwt} = \alpha_0 + \gamma T_{hwt} + \theta_w t + \beta_h + \beta_w + \beta_t + \epsilon_{hwt} \quad (2.1)$$

Where y_{hwt} represents the logarithm of day-to-day consumption of household h living in ward w in period t which takes the value 0 in the baseline period and that of 1 in the final period. Day-to-day consumption is defined as the sum of three main expenditure items namely food, communication, and transport. The sum of these costs is evaluated per adult-equivalent. We suppose that these three consumption items are relevant because they represent the day-to-day consumption of most households and are likely to change when the household's income changes. Indeed, the increase in a household's income due to its electrification could lead to a change in

its consumption habits. For example the purchase of products requiring cool storage, which was previously not possible. Although it is possible to have a mobile phone without being electrified, it could be a heavy burden in environments where charging is somewhat expensive, especially with cheaper, but poor-quality laptops or mobile phones that discharge quickly. However, access to electricity would encourage full-time use of these appliances and therefore increase the household's communication expenditure. Finally, when a household member starts a home-based business to increase household income, transport costs would increase because he/she has to travel to pay for inputs, for example.

The treatment variable is noted T_{hwt} while ϵ_{hwt} is the model's error term. The former takes the value of 1 when the household h is treated and 0 otherwise. Knowing that β_t captures time specific effects, the parameters β_h and β_w indicate unobservable fixed effects at household and ward levels respectively while θ_w captures the ward trend. Unobservable changes (θ_w) between the two periods of study could affect the treatment effect by biasing it either downward or upward if it was not included in the model. For instance, if a household head obtains a job, because of an improvement in the economic situation in his ward between t_0 and t_1 , the household income would increase. Thus, it can buy a refrigerator and start using new types of food. This additional consumption might not be possible if the household income had not increased. In this case, the effect of the treatment would be biased upwards because this income growth is not due to the connection to the electricity grid. Similarly, the treatment effect may also be influenced by certain fixed characteristics of the household's residence area. As an example, urban households do not benefit from electricity in the same way as rural households. To account for these heterogeneities³, we introduced the following variables into the model : the distance separating the household from the city center, the distance separating the household from the nearest market, the occupation status of their dwelling (owner or tenant), and the geographical slope of the area. Let X_{hw} be these control variables.

$$y_{hwt} = \alpha_0 + \gamma T_{hwt} + \lambda X_{hw} + \sigma(X_{hw} * t) + \theta_w t + \beta_h + \beta_w + \beta_t + \epsilon_{hwt} \quad (2.2)$$

In order to obtain the change in consumption due to the treatment between 2008 and 2012, we used the first difference.

$$\Delta y_{hw} = y_{hw(t+1)} - y_{hwt} = \gamma_0 + \gamma \Delta T_{hw} + \sigma X_{hw} + \theta_w + \Delta \epsilon_{hw} \quad (2.3)$$

This form allows us to avoid potential endogenous bias which could be occasioned by the specific fixed effects β_w , but mainly β_h . The constant term γ_0 is equal to $\beta_1 - \beta_0$.

The most common variable that explains the probability of electrification of an area is its degree of accessibility. To measure this, the relief (geographical slope and elevation, and vegetation cover) of the area is generally used. In addition, the transport cost of electricity from the power plant to the households' area increases with distance [Van de Walle, 2017]. This distance takes precedence over geographical characteristics since an area very close to a power plant is likely to be electrified regardless of its relief. Also, the relief can explain the economic

3. We postulate that these characteristics are not faithfully captured by the unobservable fixed effects.

status of an area, i.e. the development of economic activity in this area and the consequential change in household consumption. For instance, the geography of an area can lead to floods that would be an obstacle to the smooth running of economic activity.

Furthermore, because households use a low voltage, it is more relevant to use the distance that separates them from the nearest substation rather than from the main power station as [Van de Walle, 2017] did in the case of Indian rural households, where they analyze the impact of being connected on education and consumption. However, information about the exact geographical position of households or of substations is not available in our sample. We thus maintained as the first instrument the distance separating the household's ward from the nearest station. The probability of a ward being electrified thus decreases as this distance increases.

Otherwise, in Tanzania, connection fees vary according to the distance between the household and the nearest electricity pole beyond 30 meters [Chaplin, 2017]. To take this into account, we considered as a second instrument the distance separating the household from the nearest main road. Indeed, since electricity poles are often erected along highways, the distance between the household and the nearest major road may be used as a proxy for the distance between a power pole and the household [Salmon, 2016].

In summary, the distance separating the household's ward from the nearest power plant captures the geographical obstacle while the distance separating the household from the main road captures the size of the financial barrier to be overcome. Even if these two instruments seem *a priori* exogenous, it is not impossible that they may be related to household income. For instance, high-income households are likely to locate close to major roads and in areas with a high probability of electrification. However, this argument is insufficient to disqualify our instruments because the power plant can also be built – or the major road route built – after the installation of the household. In light of the IV approach, the model then becomes :

$$\Delta y_{hw} = \gamma_0 + \gamma \Delta T_{hw} + \sigma X_{hw} + \theta_w + \Delta \epsilon_{hw} \quad (2.4)$$

with

$$\Delta T_{hw} = \psi_0 + \psi_1 IV_{hw} + \mu_w + \pi X_{hw} + \tau_{hw} \quad (2.5)$$

The IV_{hw} instrument⁴ provides information on the probability that a household would connect to the national grid. It represents the vector of the two instrumental variables previously described. We also assume that the baseline household characteristics X_{hw} introduced into the model as control variables, cannot significantly affect their consumption when they do not benefit from the treatment.

4.2 Impact of electricity access on home-based business

Electricity plays an important role in home-based businesses in various ways. Very few authors ([Samad, 2013], [Chaplin, 2017], ESMAP 2002) have however addressed this channel but only briefly. Nevertheless, their analyses have reached the conclusion that access to electricity is

4. Data on power plants can be downloaded from the World Bank website via the link : <https://datacatalog.worldbank.org/dataset/tanzania-power-plants>

not essential for home-based business creation [Chaplin, 2017] but it does have a positive impact on the revenue of households with a home-based business [Samad, 2013]. Like the latter, we will study the case of Tanzania to determine whether households with a home-based business derive a real benefit from their electrification and how they proceed. To do this, we have grouped the data (capital stock, number of employees, etc.) by household. We can perform this grouping because the distribution of the number of people who run a home-based business does not vary according to their connection status (Appendix 1). We then use only data from the third wave of the panel and then restrict the study only to households with a home-based business. We have abandoned the panel data for the simple reason that the composition of households changes over time. If, for example, in 2008, there were three people in a household involved in a home-based business but in 2013 one of them left the household, the capital stock and/or the number of employees may decrease, thus leading to erroneous coefficients. To compensate for this, the analysis is limited to 2013 alone, which also allows us to make use of all the possible observations in the sample.

4.2.1 Electricity access and Turnover of home-based business

We analyze the effect of access to electricity on the gross income of home-based businesses as follows :

$$BusinessIncome_h = \alpha_0 + \alpha_1 E_h + \alpha_2 capitalstock + \lambda X_h + \epsilon_h \quad (2.6)$$

The variable on the left is the Business income, the variable E_h takes the value of 1 if household h is electrified and 0 otherwise; X_h is the vector of control variables and ϵ_h is the error term. As a reminder, the variable E_h is endogenous since the possession of electricity depends both on geographical accessibility and on household income. It must be instrumented to avoid biased coefficients. Here, to be valid, the instrument must be correlated with E_h without being correlated with the error term ϵ .

The proximity of a company to a major road can indeed influence its income while its proximity to a power plant has virtually no impact on its business income. However, the proximity of a major road becomes irrelevant if the household's residence area has a higher density. We have used a new instrument vector that is composed of the *distance of household from the nearest power plant*, *Power of this station* and *their interaction term*. We use the 2SLS method to correct the endogeneity of the electricity variable through the following model :

$$BusinessIncome_h = \alpha_0 + \alpha_1 E_h + \alpha_2 capitalstock_h + \lambda X_h + \epsilon_h \quad (2.7)$$

With

$$E_h = \mu_0 + \mu_1 IV_h + \mu_2 capitalstock_h + \gamma X_h + \psi_h \quad (2.8)$$

The vector X_h includes household characteristics (e.g., occupation status and size), its geographical characteristics, and some information on its activity like the *current monthly expenses*. A review of the data (Appendix 2) shows that 95% of households without capital are households

not connected to the electricity grid. Also, the average capital stock is lower among households that are not connected compared to others (Appendix 3). Therefore, we can hypothesize that the household capital endowment depends on its access to electricity. We can test this hypothesis using the “instrumental Tobit” model⁵. A selection bias in the model may arise because the capital endowment depends on the possession or not of electricity. Moreover, electrified and non-electrified households do not necessarily have the same type of equipment. Households without electricity are likely to be more equipped with purely manual or, at most, thermal equipment while electrified households are likely to have electrical machines that will necessarily have better productivity than non-electrical ones. Since the coefficient α_2 captures both the impact of electrical and non-electrical machines, it would be estimated downwards. To account for this recursion between access to electricity, capital stock, and income from the business, we use the triple-stage least-squares (3SLS) method as follows :

$$\begin{cases} capitalstock_h &= \theta E_h + \sigma X_h + \psi_h \\ BusinessIncome_h &= \alpha E_h + \beta capitalstock_h + \lambda X_h + \epsilon_h \end{cases}$$

In the first equation, the capital stock is estimated while in the second, its effect on business turnover is evaluated. Both include the variable “electricity” which is still considered endogenous and thus instrumented.

4.2.2 Electricity access and Employment of home-based business

Job creation is a key part of the economy, and anything goes when it comes to creating as many jobs as possible legally and legitimately. Even though the vast majority are small, home-based businesses sometimes need additional employees in order to be operational. In our sample, 11.82% of households have at least one employee in their businesses. Similarly, only 28.12% of households with a home-based business are connected to Tanesco. We seek here to detect a possible causal link between the possession of electricity and the creation of employment. Indeed, we have found, previously, that the accumulation of capital is observed to a greater extent in electrified households. Since capital and labor are two essential factors of production ([Douglas, 1928], [Arrow, 1961]), which may be complementary or substitutable, we suppose that access to electricity would justify the creation of employment in these households in terms of probability and number. To verify this, we constructed a binary variable ($labor_h$) that takes the value of 1 when household “h” has at least one employee and the value of 0, otherwise. We then model the probability that the household has an employee in its business as follows :

$$prob(labor_h = 1) = \alpha E_h + \beta X_h + \epsilon_h \quad (2.9)$$

$$E_h^* = \mu IV_h + \gamma X_h + \psi_h \quad (2.10)$$

5. Since the "capital stock" variable is considered to be censored at zero while "access to electricity" is endogenous and must be instrumented.

$$E_h = \begin{cases} 1 & \text{if } E_h^* \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

In this “instrumental variable Probit” model, E_h is the household connection status, X_h the control variables, and ϵ_h the error term. We use the same instrument as in the previous cases to correct for the endogeneity of *Electricity* (E_h) the variable.

Electrified households have a relatively larger business size than others. This can have a positive effect on their likelihood of having at least one employee. However, the fact that they are more capital-intensive can lead them to use fewer employees compared to non-electrified households. We verify these two opposing mechanisms using the “endogenous switching regression model” as follows :

$$Employment_h = \beta X_h + \theta E_h + \epsilon_h \quad (2.11)$$

$$E_h^* = \gamma Z_h + \lambda \epsilon_h + \psi_h \quad (2.12)$$

$$E_h = \begin{cases} 1 & \text{if } E_h^* \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

The variables X_h and E_h are identical to those described previously. In this model, the $Employment_h$ variable takes integer values and represents the number of employees used by the household’s business. The estimation of the model has two levels. The first is dedicated to the instrumentation of the endogenous binary variable, here "access to electricity" whose effect on the number of jobs created is evaluated at the last stage. At this point, we used the negative binomial model because, as shown in *Appendix 4*, the variable "number of jobs" has an over-dispersion that disqualifies the Poisson model.

5 Analysis Results

All variables used in this section are defined in Appendix 5. The results concerning consumption analysis are summarized in Table 2.4 which presents four linear regression models. The first is estimated with the ordinary least square (OLS) estimator which assumes that the treatment is exogenous. Its results reveal that access to electricity has a positive, but not statistically significant impact on household consumption. When we move to the models estimated from the two-stage least square (2SLS) method which assumes that the treatment is endogenous, the results change systematically (in size) and the instrumental variables are positive and statistically significant at least at 10% in all model specifications. However, our instrument is not totally immune to criticism. The low value of the R-square parameter in the first step equation leaves some doubt about the power of these instruments. Nevertheless, all these first steps are significant regarding their F-statistics. Our small sample size constrains us to consider only the regional trend since both the number of wards and the number of districts are very high. This

TABLE 2.4 – Electricity access effect on household consumption

VARIABLES	1 OLS	2 ΔT	$\Delta Cons$	3 ΔT	$\Delta Cons$	4 ΔT	$\Delta Cons$
owner	0.184***	-0.079**	0.292***	-0.070**	0.339***	-0.078**	0.296***
idistm	0.309	0.288*	-0.477	0.282	-0.418	0.301*	-0.531
idistv	0.385*	0.307***	0.142	0.182*	-0.107	0.295***	0.136
idistr		0.046**		0.062***		0.047**	
IDPP		0.279***		0.202**		0.266***	
ΔT	0.038		1.110*		1.912**		1.202*
slop_reg						-0.005***	0.012
Constant		0.088***	-0.035	0.052	-0.206	0.114***	-0.102
region fixed effects	Yes			Yes	Yes		
Observations		2,334	2,334	2,334	2,334	2,334	2,334
R-squared		0.095		0.150		0.097	
F-statistic		15.10		6.05		13.62	
Wooldridge(p_endog)			0.0901		0.0192		0.0786
Wooldridge(p_overid)			0.733		0.987		0.806

Note : * pvalue<0.1; ** pvalue<0.05; *** pvalue<0.01; In all models, the dependent variable is the change in household consumption between 2008 and 2012 ($\Delta Cons$) while the variable of interest (i.e., treatment) is the connection to the electricity grid (ΔT) between 2008 and 2012. The inverse of the distances is considered in the models for compliance. The slope of the regions (slop_reg) is sometimes considered instead of the fixed effects. This reduces the number of parameters to be estimated and could improve the reliability of the results.

Source : author's calculation

trend is captured by dummies in models 1 and 3. In the last model, it is replaced by the geographical slope which is a continuous variable. These models reveal that access to electricity has a positive and statistically significant effect on household consumption. The latter doubles or even triples when households get electricity. The high value of these coefficients might not hide anything extraordinary. In addition to all the transmission channels listed above, these high values may be justified by the fact that when the purchasing power of households increases, their preference for superior goods would increase to the detriment of inferior goods. Therefore, the high value of the impact of the treatment does not necessarily mean an increase in the volume consumed but rather an increase in expensive products. Finally, the results also capture economic recovery effects after the 2008 financial crisis [Ngowi, 2010]. Indeed, some developing countries, particularly Tanzania, adopted policies to minimize the effects of the crisis ([Naudé, 2009], [Te Velde, 2008]). In Tanzania, these included the use of expansionary monetary and fiscal policies (reducing tax rates and increasing subsidies for both producers and consumers of goods and services) in general and appropriate policy tools such as increasing money supply and reducing interest rates [Ngowi, 2010]. These policies could boost household consumption, mainly that of electrified households that own home-based enterprises. For instance, if the population's income increases on average due to these different policies, demand would also increase, leading to an increase in the turnover of all companies including home-based businesses. Finally, there is an increase in household income and ultimately in consumption.

Concerning the analysis of home-based activity, the results in Table 2.5 show that access to electricity increases households' activity income by 75.6% (2sls model). Similarly, activity-related expenditure and household size have a positive and statistically significant effect on income. As for the capital stock, an increase of 1% leads to an increase of about 25% in activity income according to the 2sls estimates. The results of the IV Tobit model corroborate our hypothesis about the relationship between capital endowment and access to electricity. They reveal that

TABLE 2.5 – relationship between home-based business incomes and electricity access

VARIABLES	2sls		IV Tobit	
	tanesco	ln(Income)	ln(Cap_stock)	tanesco
ln(Cap_stock)	0.053***	0.247***		
household size	0.002	0.026**	0.105***	0.010**
spending	2.27e-08	4.77e-07***		
owner	-0.144***	0.052	0.537**	-0.123***
idistv	0.700***	0	-0.696	0.895***
idistm	0.285	0		
IDPP	0.890***			1.206***
Power	0.002***			0.002***
IDPP2	-1.072***			-1.490***
Power2	-5.32e-06***			-5.02e-06***
IDPP*Power	0.004*			0.005**
tanesco		0.756***	2.282***	
slop_ward			-0.010	-0.004
Constant	-0.391***	8.936***	9.857***	0.176***
Observations	817	817	844	844
R-squared	0.286	0.483		
F-statistic	37.22			
Wooldridge(p_endog)		0.150		
Wooldridge(p_overid)		0.346		

Note : * pvalue<0.1 ; ** pvalue<0.05 ; *** pvalue<0.01. The table shows how access to electricity affects the income of home-based businesses without considering that physical capital endowment is endogenous. This endogeneity is proved in the second part of the model through the Tobit IV estimator. Five instruments (IDPP, Power, IDPP2, Power2, and IDPP*Power) are used here to correct the endogeneity of access to electricity. The Wooldridge test does not reveal any problem of overidentification.

Source : author's calculation

access to electricity can induce a nearly twofold increase in capital stock.

According to the results of the 3sls estimator (Table 2.6), the effect of the household's access to electricity on capital increases from 3 to 5 while the increase of 1% in the capital stock results in an increase from 45% to 60% in home-based businesses gross income. These results confirm that the effect of the physical capital stock is underestimated in Table 2.5. We describe this effect as the “indirect effect” of electricity on the business' income. The direct effect is identified in model 3 (Table 2.6) where we insert the variable *tanesco* that represents “access to electricity”. Its coefficient is not significant but positive. We, therefore, deduce that electricity only acts indirectly on the household business's income. This means that a household can only benefit from electricity in its business if it is well-endowed in physical capital. This conclusion then refutes the hypothesis that electric lamps would prolong daily working time and thus increase the income of home-based businesses.

Table 2.7 reports the effects of access to electricity on job creation in home-based companies. In model “M1”, the variable *capital stock* is in a continuous form and whereas in model “M2” it is in categorical form. The third model does not include this variable. These three models suggest that access to electricity does not necessarily indicate the presence of employees in their business. However, the capital stock has a positive and statistically significant effect on job creation. It

TABLE 2.6 – Relationship between electricity and gross income of home-based businesses

VARIABLES	1		2		3	
	ln(Cap_stock)	ln(Income)	ln(Cap_stock)	ln(Income)	ln(Cap_stock)	ln(Income)
ln(Cap_stock)		0.593***		0.519***		0.455***
spending		4.28e-07***		4.14e-07***		4.05e-07***
household size	0.100***	-0.012	0.087***	-0.001	0.086***	0.004
owner	0.707***	-0.156	0.931***	-0.125	0.948***	-0.063
idistm		0.590		0.897		0.724
idistv	-1.457**	-0.130	-11.89***	-0.206	-12.83***	-0.352
idistr		-0.160		-0.071		-0.105
slop_ward	-0.004	-0.012	-0.001	-0.014	-0.001	-0.013
tanesco	3.117***		4.635***		4.748***	0.346
idistv2			17.29***		18.90***	
Constant	9.569***	5.674***	9.542***	6.410***	9.548***	6.995***
Observations	817	817	817	817	817	817
R-squared	0.072	0.292	-0.101	0.377	-0.121	0.426

Note : * pvalue<0.1; ** pvalue<0.05; *** pvalue<0.01. The results in this table are obtained using the 3SLS estimator. We have two dependent variables (income and capital). Access to electricity is always endogenous and thus instrumented with the two instruments used in equation 2.5 i.e. idistr and IDPP.

Source : author's calculation

increases by 30.2% the probability that the household creates jobs as a result of an infinitesimal increase in its average. However, this effect is local because the relationship between capital stock and the probability of having an employee is non-linear in this model. The model "M2" supports the previous result by reporting a positive and statistically significant effect of capital stock. The correlation between the capital stock and access to electricity could lead to the non-significance of the coefficient of the latter. To overcome this, we excluded the variable *capital stock* (M3). Model "M3" shows that the coefficient of variable E_h is still not statistically significant. According to the ESR model (M4), access to electricity reduces the number of employees used by the household, but this effect is not statistically significant. As for the capital stock, its impact continues to be statistically significant. Indeed, capital endowment significantly increases the number of jobs created in home-based businesses. We deduce that having electricity is not enough for households to create jobs, they also need physical capital. Since access to electricity generates capital accumulation, the effect of capital stock on employment can also be described as an indirect effect of electricity on employment.

TABLE 2.7 – Electricity and household employment creation

VARIABLES	M1		IV Probit M2		M3		ESR model M4	
	Pr(labor=1)	tanesco	Pr(labor=1)	tanesco	Pr(labor=1)	tanesco	Employment	tanesco
tanesco	0.470		0.869		0.832		-0.855	
urban	-0.489*	0.239***	-0.485**	0.238***	-0.278	0.277***		
owner	-0.085	-0.114***	0.025	-0.117***	0.094	-0.101**	-0.062	-0.393***
household size	0.003	0.005	0.009	0.006	0.035*	0.013***	0.068	
2.stk			0.082	0.100***				
3.stk			0.660**	0.106**				
4.stk			0.892***	0.180***				
5.stk			0.983**	0.354***				
6.stk			1.644***	0.427***				
ln(Cap_stock)	0.302***	0.054***						
IDPP		0.211		0.211**		0.215**		1.189***
idistr		0.282***		0.284***		0.298***	1.950**	1.324***
Cap_stock							6.37e-08***	
idistv							-3.116**	
idistm							1.484	
Constant	-2.526***	-0.058	-1.989***	0.021	-1.603***	0.083*	-4.201***	-0.841***
Observations	844	844	892	892	892	892	914	914
sigma							2.266***	
rho							0.467***	

Note : * pvalue<0.1 ; ** pvalue<0.05 ; *** pvalue<0.01. The two instruments used in equation 2.5 are used here to correct for the endogeneity of access to electricity. The "physical capital" variable is used in logarithmic form in model M1, in discrete form in model M2, and without any discrete form in model M2, and without any transformation in model M4. It is not included in model M3. The dependent variable is the number of jobs created per household, while the variable of interest is access to electricity.

Source : author's calculation

6 Robustness

To estimate the treatment effect on household consumption, we referred to an instrumental variable method. We continue with this method by calculating an interval of treatment effect under certain conditions. According to the Wooldridge test, the treatment's exogeneity is often rejected at the 10% level, this may be due to the poor quality of the instrument which would, in turn, have resulted in the high coefficients that we obtained. Another approach to address the endogeneity issue of treatment is the use of non-parametric methods. Here, we use a difference-in-difference matching approach.

6.1 Bounds of possible treatment effects

The study of causal relationships is becoming increasingly inescapable in social sciences. This justifies the current use of instrumental variables (IV) in many papers, in the social sciences, and particularly in economics, given that it is difficult to obtain completely exogenous variables. However, obtaining a valid IV raises two key challenges. Let ⁶ :

6. As an example, we consider an explanatory variable and an instrumental variable

$$Y = \beta X + \gamma Z + \epsilon \tag{2.13}$$

$$X = \pi Z + \zeta \tag{2.14}$$

Y is the endogenous variable to explain, and X is the explanatory variable of interest that should be exogenous but is suspected to be weak. Vector Z is that of the instrumental variables. X is endogenous when it is correlated to ϵ , thus leading the β coefficient to be inconsistent with the “ols” estimator. Instrument Z is therefore called upon to correct this bias. To be valid, Z must be strongly correlated with X (first condition) and must explain Y only by X (second condition that implies $\gamma = 0$). That means that the instrument must be exogenous and therefore not correlated to ϵ . However, it is difficult to find an instrument that faithfully respects both conditions. If having an instrument correlated to X is relatively easy, this is not the case for the second condition. Instruments that do not simultaneously satisfy these two assumptions often lead to less satisfactory results. In order to facilitate their use, recent studies ([Small, 2007], [Nevo, 2012],[Hotz, 1997], [Conley, 2012]) have proposed alternatives that partially validate these types of instruments by allowing, for example, γ coefficients to belong to an interval ($[\gamma_{min}, \gamma_{max}]$) rather than being equal to 0 [Conley, 2012] or by accepting a non-zero correlation between Z and ϵ [Nevo, 2012] in a given interval so that the β coefficient is estimated as an interval and not as a point estimate. We have to calculate these intervals among which treatment effects can vary for each specification because the instrument may influence household consumption independently of the household electrification status. For instance, the proximity of a household's ward to a power plant can lead to a massive presence of businesses. This would allow household members to gain employment and improve their income and hence their consumption. Table 2.8 presents the possible intervals of treatment effects using the approach of [Conley, 2012].

TABLE 2.8 – Possible intervals of treatment effects

idistr	$\gamma_{min} = 0 \ \gamma_{max} = 0.1$	$\gamma_{min} = 0 \ \gamma_{max} = 0.2$	$\gamma_{min} = 0 \ \gamma_{max} = 0.1$
ID	$\gamma_{min} = 0 \ \gamma_{max} = 0.3$	$\gamma_{min} = 0 \ \gamma_{max} = 0.4$	$\gamma_{min} = 0 \ \gamma_{max} = 0.3$
model 2	[-.688 1.280]		
model 3	[-1.173 1.280]		
model 4	[-.688 1.280]		

Source : author's calculation

It presents the possible ranges of the treatment effect if a small correlation is allowed between the dependent variable (consumption change) and the instruments. The upper bound of each of these intervals is determined following a linear regression (ols) of the dependent variable on the instruments and the other explanatory variables. We deduce from this table that the coefficient of each model is in the corresponding interval except in the second specification where the effect of the treatment is outside the range. We also note that the three upper bounds are all identical. This means that the effect of the treatment can in no case exceed 1.280.

6.2 Difference-in-difference matching with Mahalanobis distance

Difference-in-difference (DiD) is a powerful tool used in research and especially in economics, to evaluate the effect of a project or development program on its beneficiaries. With data on participant and control observations before and after program intervention, a DiD estimator can be constructed. Its particularity is that it allows for unobserved characteristics affecting program take-up, assuming that these unobserved traits do not vary over time. It also assumes that, in the absence of treatment, the explained variable (i.e. consumption in our case) must adopt the same trend in both treatment and control groups. This assumption may not be verified if some characteristics that may influence changes in the variable of interest do not have the same distribution in the two groups ([Abadie, 2005], [Bensch, 2011], [Khandker, 2009]). This is the problem that the Propensity Score Matching, based on Mahalanobis distance [Rosenbaum, 1985], solves by forcing the similarity of the two groups through carefully selected features. The method follows three stages. The first stage is to estimate the predicted value p_h (propensity score with logit or probit) of household “h”’s access to electricity as a function of the household characteristics and its ward attributes. In the second stage, we select all untreated households j such that $|p_j - p_h| < c$ where “c” is the caliper constant. From this selected subset, we match the treated and untreated households that are closest in the sense of the Mahalanobis distance D_{hj} [Rubin, 2000], based on variables Z , where :

$$D_{hj} = \begin{cases} (Z_h - Z_j)^t \Sigma^{-1} (Z_h - Z_j) & \text{if } |p_h - p_j| \leq c \\ +\infty & \text{if not} \end{cases}$$

and Z is the set of key covariates. σ is the variance-covariance matrix of Z . The Caliper c is a function of standard deviation, and a low value is necessary when the variance in the treatment group is much larger than that in the control group. [Rosenbaum, 1985] suggests a caliper of 0.25 standard deviations of the linear propensity score.

The third stage estimates the Average Treatment effect on the Treated (ATT) by matching and weighting the control group by the predicted values or a function of these. This combination is known as *difference-in-difference matching*.

Let us denote by $Y_{ht}(D)$ the consumption of household h at the period $t \in (0,1)$ and D the treatment variable which takes 1 if the household is treated and 0 otherwise. We use the following assumptions :

Assumption 1 :

$$E(Y_1(0) - Y_0(0)|X, G = 1) = E(Y_1(0) - Y_0(0)|X, G = 0) \quad (2.15)$$

Assumption 2 :

$$P(D = 1) > 0 \quad \text{and} \quad P(D = 1|X) < 1 \quad (2.16)$$

where G is the household group. It takes the value of 1 if the household belongs to the treatment group and the value of 0 if it is in the control group. The Vector X contains household

characteristics (in $t = 0$), which are used for the matching. Equation 15 reflects the common trend hypothesis. It states that conditional on the vector X , the expenditure of the households in groups 1 and 2 maintains the same gap between 2008 ($t = 0$) and 2012 ($t = 1$) if no household receives the treatment. The second hypothesis, on the other hand, requires the presence of treated households in the Treated sample with an uncertain probability proving its status of treated, conditional on the pairing characteristics.

On validation of these two hypotheses, the effect of the treatment is evaluated by the following formula :

$$ATT_{PSM}^{DiD} = \frac{1}{N} \left[\sum_{i \in G=1} (Y_{i1} - Y_{i0}) - \sum_{j \in G=0} \omega(i, j) (Y_{j1} - Y_{j0}) \right] \quad (2.17)$$

Equation 17 represents the effect of treatment on the *treated*. The weighting value derives from the characteristics of the households (owner or tenant) and their dwellings (walls, roof, and floor). These characteristics approximate their income levels. It also contains other characteristics to control for their geographical accessibility and similarity. This is the ward slope, the distance separating it from the (nearest) main road, and finally the distance to the nearest town center. The results of this estimation are displayed in Appendix 7. The variable *consumption* (Y) is expressed in logarithmic form. Appendix 6 shows that pairing is possible because of the existence of common support. According to the results, the households that received the treatment experienced an increase in their consumption of around 26.33%. Although this is lower than the values found in Section 4, it is significant and proves that households' access to electricity affects their consumption. Since it is a non-parametric method, the values obtained are conditional and depend a little on the chosen pairing variables. So we do not have enough evidence to refute the robustness of our results. We just retain here that treatment has a positive and significant effect on treated households and in addition, it is contained in all the intervals found in the previous table.

Conclusion

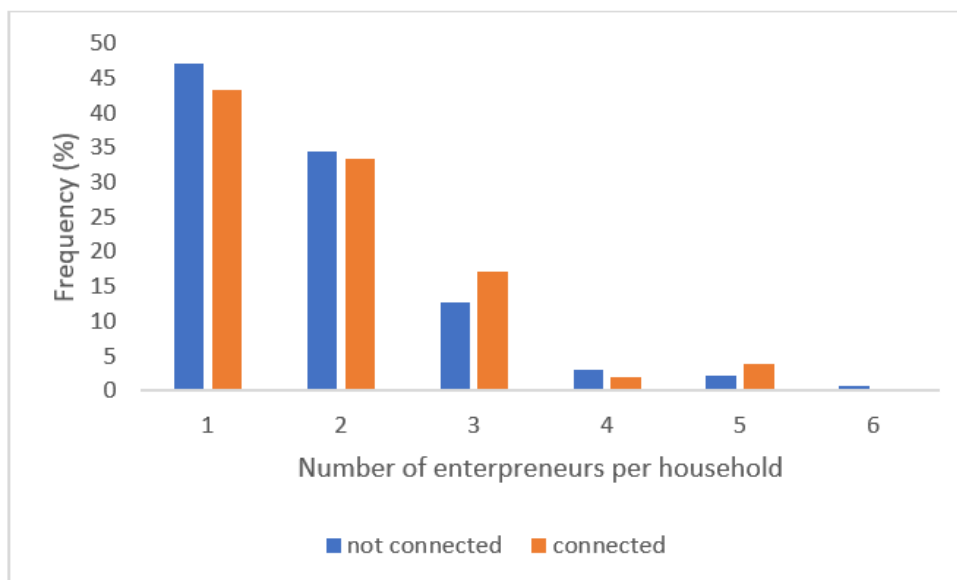
This paper considers the effect of the electrification of households on their overall well-being in Tanzania. Our analyses reveal that households can observe a growth in consumption of up to 120% due to their connection to the electricity grid. The specificity of this paper is the fact that it is interested in one of the potential channels through which electricity has an effect on households' income, which is the home-based business and the related externality, i.e. job creation. We found that electrified households that own a home-based business have larger capital stock than non-electrified households. This capital endowment explains the difference in their business's gross income. Since the possession of electricity does not affect the gross income of home-based businesses without acting through capital stock, we have treated this effect as indirect rather than direct. The provision of electricity in Tanzania is not therefore enough for households to generate income and employment because our results showed that they must have a large stock of physical capital in addition. In conclusion, we can say that electricity benefits

households with capital stock which in turn can positively impact the income of their neighbors by offering them jobs.

Most of these households work in the informal sector, which is the main provider of jobs in Africa (ADB, 2019). However, since the actors of this sector do not have administrative documents, access to bank credit is almost impossible. This explained part of the difficulties experienced by workers in this sector and the precariousness of their working conditions. For this sector to be economically viable and to contribute significantly to national production, it would be necessary not only to offer its actors electricity but also to support them through financial inclusion policies that affect all social strata. Indeed to take advantage of electricity, households that have a business in their home need to invest in physical capital. This will not be possible if the household faces financial constraints. In that case, they must receive help from microfinance organizations or banks for possible loans to equip their companies.

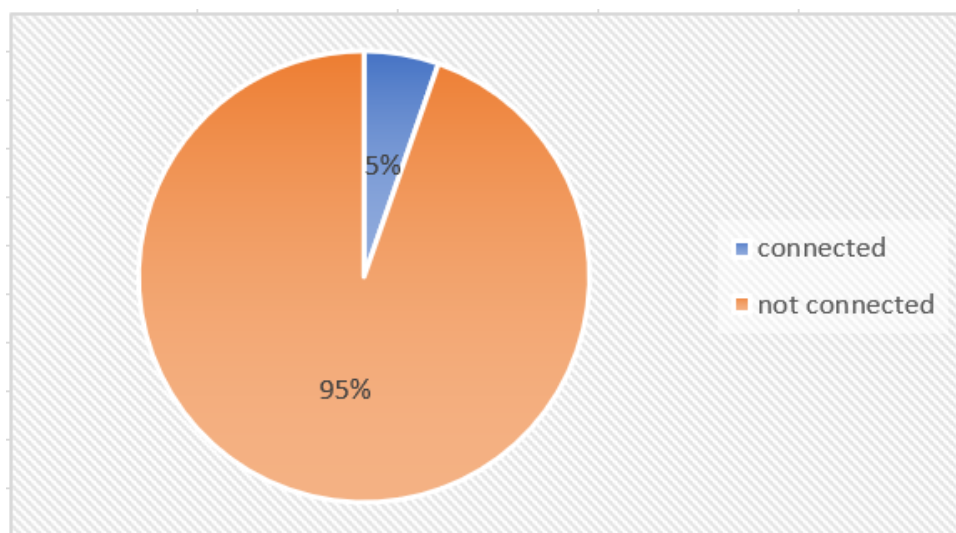
7 Appendixes

Appendix 1 : Number of entrepreneurs per household (in 2012) among connected and non-connected



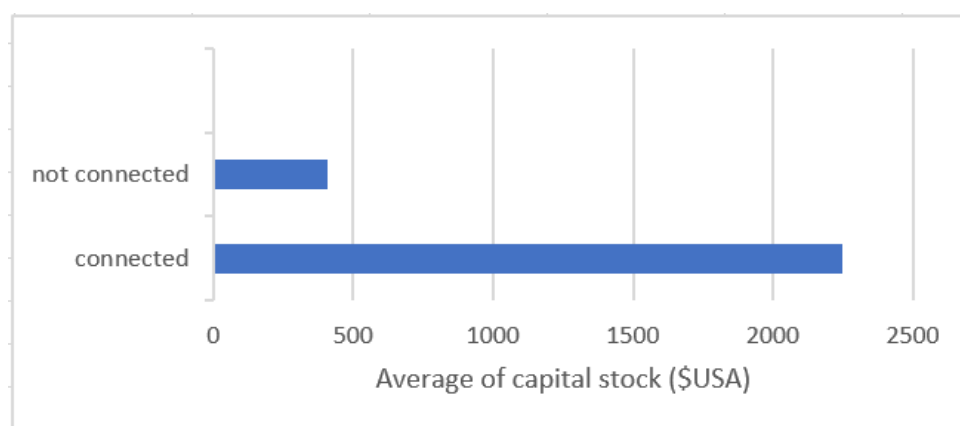
Source : Own elaboration

Appendix 2 : Share of households without capital stock



Source : Own elaboration

Appendix 3 : Average capital stock by connection status



Source : Own elaboration

Appendix 4 : Number of jobs created in home-based businesses

Number of Jobs	0	1	2	3	4	5	6	8	10	14	15	95
Frequency (%)	88.18	6.02	2.19	1.31	0.98	0.33	0.22	0.18	0.33	0.11	0.11	0.11

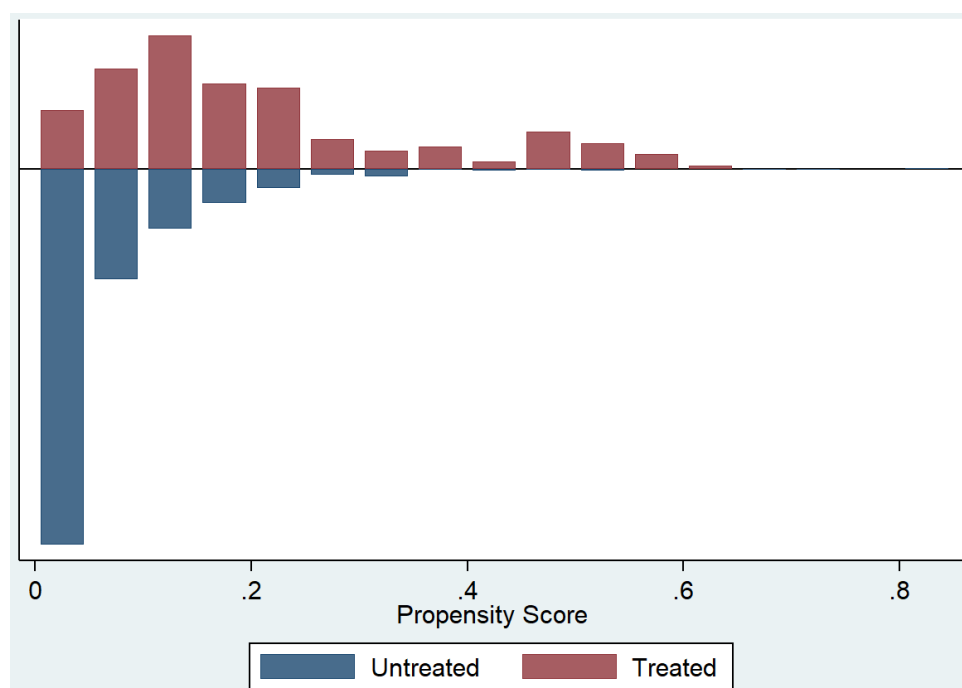
Note : The table shows the number of outside employees per household. An outside employee is not a member of the household and therefore earns an hourly, daily, or monthly wage, etc. It can be deduced from the table that most households (about 88%) do not use these types of employees. Those that do, often employ one employee. However, others may employ two (6.02%), three (1.31%), etc., or even several dozen.

Appendix 5 : Definition of models' variables

Variables	Definions
owner	Binary variable taking 1 when the household owns the house or housed and 0 otherwise
idistm	inverse of the distance between the household and the nearest market
idistv	Inverse of the distance between the household and the nearest city center
idistv2	Square of the variable idistv
idistr	Inverse of the distance between the household and the nearest main road
IDPP	Inverse of the distance between the household ward and the nearest power plant
IDPP2	Square of the variable IDPP
ΔT	Treatment variable, takes 1 when the household connects to Tanesco between 2008 and 2012 and 0 otherwise
slop_reg	Regional geographical slope
tanesco	Tanzania Electric Supply Company
urban	Takes 1 when the household resides in an urban area and 0 otherwise
household size	Household size assessed in adult equivalent
1.stk	Household physical capital stock is in the range [0-10 [(US \$)
2.stk	Household physical capital stock is in the range [10-50 [(US \$)
3.stk	Household physical capital stock is in the range [10-100 [(US \$)
4.stk	Household physical capital stock is in the range [100-500] (US \$)
5.stk	Household physical capital stock is in the range [500-1000[(US \$)
6.stk	Household physical capital stock is in the range [1000-65000] (US \$)
ln(Cap_stock)	Logarithm of capital stock
spending	Household expenses related to its business
Power	Power of the plant closest to the household ward
Power2	Power variable square
IDPP*Power	Product of IDPP and Power
slop_ward	Geographic slope of the household ward
$\Delta Cons$	Consumption change between 2008 and 2012

Note : we have considered the inverse of the distances because in most cases there is a negative correlation between the instrument (distance to the nearest major road and distance to the nearest power plant) and the variable to be explained (access to electricity). Thus, with the intention of having a positive sign, we took their inverse. For convenience, we also took the inverse of all other distances. However, since some distances are zero, we added "1" to all of their values to avoid missing observations. This is a personal choice with no scientific basis.

Appendix 6 : Propensity score histogram



Source : Own elaboration

Appendix 7 : Difference-in-Difference matching results

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
$\Delta \log(dep)$	Unmatched	.358	.294	.064	.059	1.07
	ATT	.358	.095	.263	.114	2.31

Treatment assignment	common support
Untreated	2147
Treated	167

Appendix 8 : Characteristics of households and individuals in 2012

Characteristics	Frequency (HbES)	Percentage	Frequency (GS)	Percentage	HbES/GS
Relation with household head	1117	100%	25412	100%	
HEAD	619	55.42	5010	19.72	12.36
SPOUSE	334	29.90	3485	13.71	9.58
SON/DAUGHTER	90	8.06	10843	42.67	0.83
STEP-SON/DAUGHTER	4	0.36	542	2.13	0.74
SISTER/BROTHER	7	0.63	448	1.76	1.56
GRANDCHILD	10	0.90	2728	10.74	0.37
FATHER/MOTHER	6	0.54	200	0.79	3.00
OTHER RELATIVE	38	3.40	1767	6.95	2.15
LIVE-IN SERVANT	2	0.18	150	0.59	1.33
OTHER NON-RELATIVES	7	0.63	239	0.94	2.93
Gender		100%	25412	100%	
MALE	472	42.26	12351	48.60	3.82
FEMALE	645	57.74	13061	51.40	4.94
Main Occupation (last 12 months)		100%	25206	100%	
AGRICULTURE/LIVESTOCK	497	44.49	7330	29.08	6.78
FISHING			105	0.42	0.00
MINING	5	0.45	36	0.14	13.89
TOURISM			4	0.02	0.00
GOVERNMENT	24	2.15	420	1.67	5.71
PARASTATAL	1	0.09	40	0.16	2.50
PRIVATE SECTOR	39	3.49	1204	4.78	3.24
NGO/RELIGIOUS	1	0.09	59	0.23	1.69
SELF-EMPLOYED	508	45.48	1692	6.71	30.02
UNPAID FAMILY WORK	30	2.69	1761	6.99	1.70
PAID FAMILY WORK			91	0.36	0.00
JOB SEEKERS	2	0.18	71	0.28	2.82
STUDENT	4	0.36	6552	25.99	0.06
DISABLED	3	0.27	316	1.25	0.95
NO JOB	3	0.27	990	3.93	0.30
TOO YOUNG			4535	17.99	0.00
Marital Status		100%	16674	100%	
MONOGAMOUS MARRIED	528	47.35	5540	33.23	9.53
POLYGAMOUS MARRIED	114	10.22	1155	6.93	9.87
LIVING TOGETHER	135	12.11	1265	7.59	10.67
SEPARATED	60	5.38	595	3.57	10.08
DIVORCED	66	5.92	408	2.45	16.18
NEVER MARRIED	116	10.40	6857	41.12	1.69
WIDOW(ER)	96	8.61	854	5.12	11.24

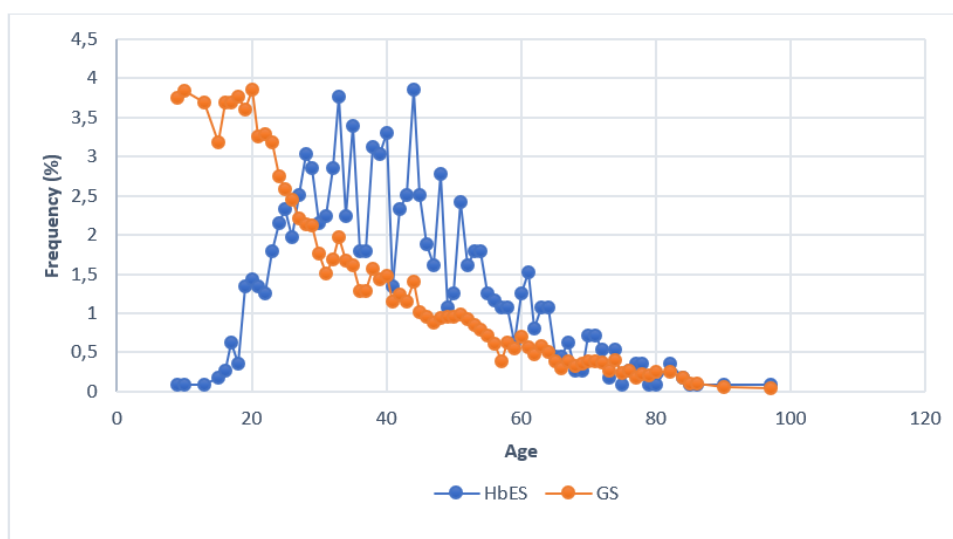
Note : HbES means Home-based Enterprise Sample while GS is Global Sample

Appendix 8 (continued)

Characteristics	Frequency (HbES)	Percentage	Frequency (GS)	Percentage	HbES/GS
Study Level		100%	10000	100%	
PP			7	0.07	0.00
ADULT			4	0.04	0.00
D1	5	0.54	95	0.95	5.26
D2	21	2.26	258	2.58	8.14
D3	25	2.69	291	2.91	8.59
D4	67	7.22	740	7.40	9.05
D5	16	1.72	283	2.83	5.65
D6	16	1.72	309	3.09	5.18
D7	532	57.33	5411	54.11	9.83
D8	11	1.19	100	1.00	11.00
PREFORM 1	1	0.11	9	0.09	11.11
MS+COURSE	18	1.94	117	1.17	15.38
F1	16	1.72	126	1.26	12.70
F2	47	5.06	548	5.48	8.58
F3	31	3.34	236	2.36	13.14
F4	78	8.41	971	9.71	8.03
'O'+COURSE	21	2.26	224	2.24	9.38
F5			5	0.05	0.00
F6	5	0.54	44	0.44	11.36
'A'+COURSE	4	0.43	33	0.33	12.12
DIPLOMA	6	0.65	76	0.76	7.89
U2	2	0.22	3	0.03	66.67
U3	4	0.43	56	0.56	7.14
U4			21	0.21	0.00
U5&+	2	0.22	33	0.33	6.06
Occupation	914	100%	5008	100%	18.25
Owner	778	85.12	4047	80.81	19.22
Tenant	136	14.88	961	19.19	14.15
Residence area	914	100%	5010	100%	18.24
Urban	361	39.50	1791	35.75	20.16
Rural	553	60.50	3219	64.25	17.18

Note : HbES means Home-based Enterprise Sample while GS is Global Sample

Appendix 9 : Distribution of surveyed individual ages in 2012



Source : Own elaboration

Commentary to Appendixes 8 and 9

Appendix 8 presents the main characteristics of individuals and households both in the home entrepreneur sub-sample (HbES) and in the global sample (GS). The last column assesses the proportion, compared to the entire sample, of individuals and households involved in home-based activities according to the characteristics considered. The figure in Appendix 9 shows the age distribution in the subsample (HbES) and the aggregate sample (GS). It appears from this description that home-based entrepreneurship is largely observed in households owning their houses and is practiced mainly by heads of households (both genders combined) or by their spouses. In urban areas, there are more households (20.16%) engaging in home-based entrepreneurship compared to rural areas (17.18%). It represents an alternative i.e. a secondary activity for individuals whose main activity is seasonal (e.g. agriculture). It especially includes young people of all ages (16-50 years) and all levels of study, the majority of which are the lowest.

Synthesis

Household electrification offers people several possibilities. It improves their well-being through several dimensions such as health, education, and economic situation. The latter case manifests itself through several channels including home entrepreneurship.

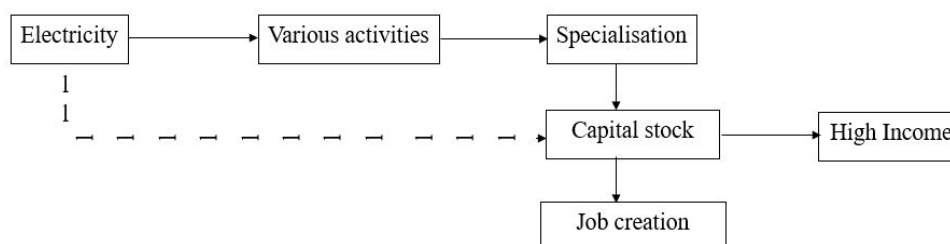
Distribution of activity sectors by household and individual

status	Individual	Households	Activity	Activity by pers	Activity by household
not connected	939	657	56	0.060	0.085
connected	383	257	45	0.117	0.175

Source : Author's calculation

The above table shows the distribution of household activity sectors according to their electrification status. We deduce that in the rank of non-electrified households, six to eight (to nine) distinct activities are available respectively per hundred individuals and hundred households, while this is doubled for electrified households. Based on these statistics and our econometric results, we can say that the electrification of households gives rise to new and diverse activities.

Mechanism



Source : Own elaboration

This diversification generates a widening range of activity sectors in which households and individuals specialize. This leads to lower competition compared to the case of non-electrified households that have to struggle more to maintain their market share. However, the electrified activities require a relatively high investment in physical capital, a necessary condition to benefit from a high activity income and to create jobs. Figure 7 summarizes these main channels.

Chapitre 3

Advent of Chinese goods into African markets : Impact on firms' growth

Dans cet papier, nous évaluons les effets du commerce Chine-Afrique sur la croissance des entreprises africaines. Pour ce faire, nous avons utilisé les bases de données "EnterpriseSurveyData" de la Banque mondiale, "Eora" (Input-Output) et "BACI" du CEPII. Les résultats obtenus par la méthode de Variable Instrumentale montrent que les produits chinois constituent une menace pour la croissance des entreprises africaines. La pénétration de la Chine sur le marché africain entraîne une baisse significative des ventes et de la taille des entreprises. En outre, en examinant les entreprises selon plusieurs caractéristiques, nous constatons que les petites entreprises, les jeunes et celles moins capitalistiques sont les plus vulnérables. Cependant, nous avons également remarqué que les entreprises des pays dépendants de ressources naturelles sont moins susceptibles d'être victimes de la pénétration chinoise sur leur marché. Enfin, les entreprises africaines subissent de plein fouet le choc chinois sur les marchés extérieurs communs, avec une ampleur plus considérable dans les pays développés.

1 Introduction

Initially, international trade was based on the theory of comparative advantage and was therefore done for the sake of complementarity. Each country brought to the international market the goods whose production costs it as little as possible. In doing so, the exchanges were of a North-North and North-South nature. In the first category, high-tech goods were traded. For example, a country that has a comparative advantage in manufacturing ships could trade with another that has a comparative advantage in manufacturing airplanes. In the second category, less developed Southern countries needed high-tech goods, in which Northern countries held a monopoly, for the construction of infrastructure. The countries of the North, for their part, needed abundant and untapped raw materials from the Southern countries, which also had a comparative advantage in the production of labor-intensive goods. Despite their importance, these exchanges resulted in almost limited growth in the total volume exchanged until the late 1960s (Figure 3.1). In the 1970s, international trade began to take off due to an intensive and

extensive expansion of international trade (IT). The intensive development was explained by a rapid increase in the total volume traded by the old IT players while the extensive expansion was the result of the appearance of new products in the international market, due to technical progress. Furthermore, the extensive development of IT can also be attributed to the appearance of new players in the international market, particularly in African countries. In the 1960s, several African countries gained their independence. To build their economies, they had to trade with the rest of the world to procure necessary goods that they had neither the capacity nor the knowledge to produce. From the 1990s, South-South trade grew faster than North-North and North-South; the total volume traded between Southern countries became an important part of their total trade with the rest of the world. However, the share traded with the Northern countries remained the highest. The advent of China as a global trading partner in the early 2000s marked a turning point in international trade. As shown in Figure 3.1, international trade

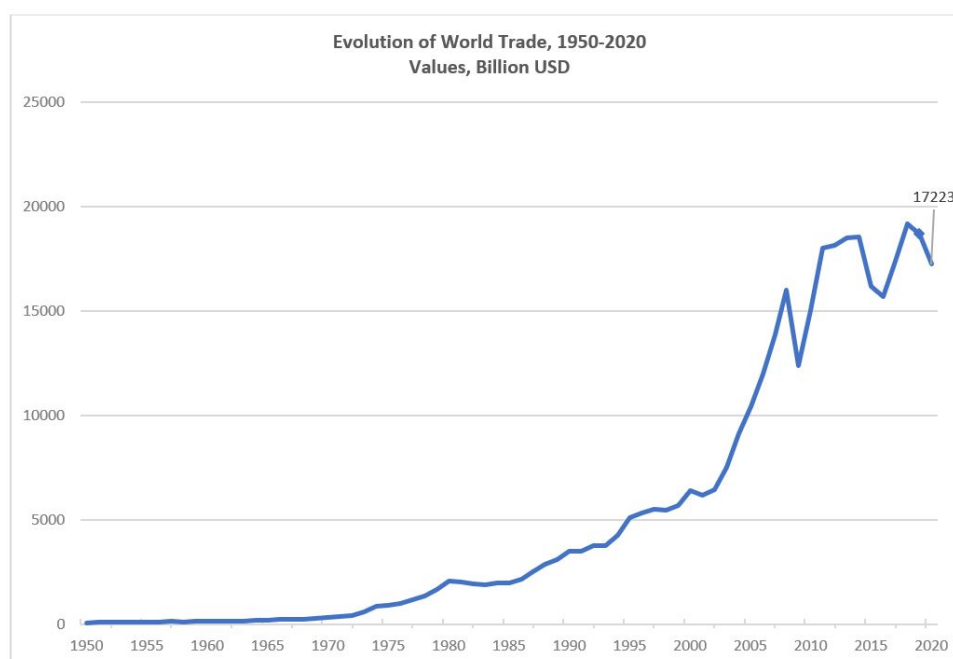


FIGURE 3.1 – Evolution of world trade

increased dramatically after China lowered tariffs and joined the WTO in 2002. The diffusion of Chinese products on the international market eroded the market share of the former players as shown in Figure 3.2. The respective shares of the European Union, the USA, and Japan experienced a gradual and persistent decline over the period 2000-2015 while that of China grew spontaneously over the same period. China's breakthrough into the international market is qualified as the *Chinese shock* because it was unpredictable and unexpected. But what about Africa? How did the continent experience the Chinese shock and what are the repercussions on its trade with the rest of the world?

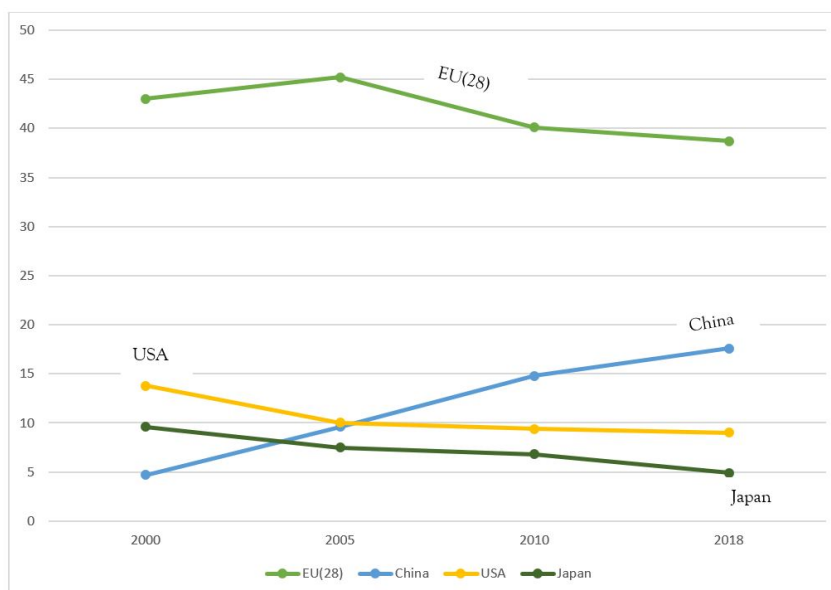


FIGURE 3.2 – Share in world exports (%) of major players in world trade (source : WTO)

China has played and continues to play a remarkable role in opening Africa to trade. To understand the advantages and disadvantages of trade linking Africa and the rest of the world, it is important to distinguish two periods : pre-China and post-China WTO accession. In the first period, Africa only had two main partners, the European Union, and the United States. These countries are known for their high-tech products while Africa was known for its low-tech and labor-intensive products. The clear difference between these trading partners and their products generated little competition in the African market. But after China's accession to the WTO, the situation changed. Indeed, China is able to produce a wide range of any given product, from low to high quality. Thus, two types of competition arise in the African market. On one hand,

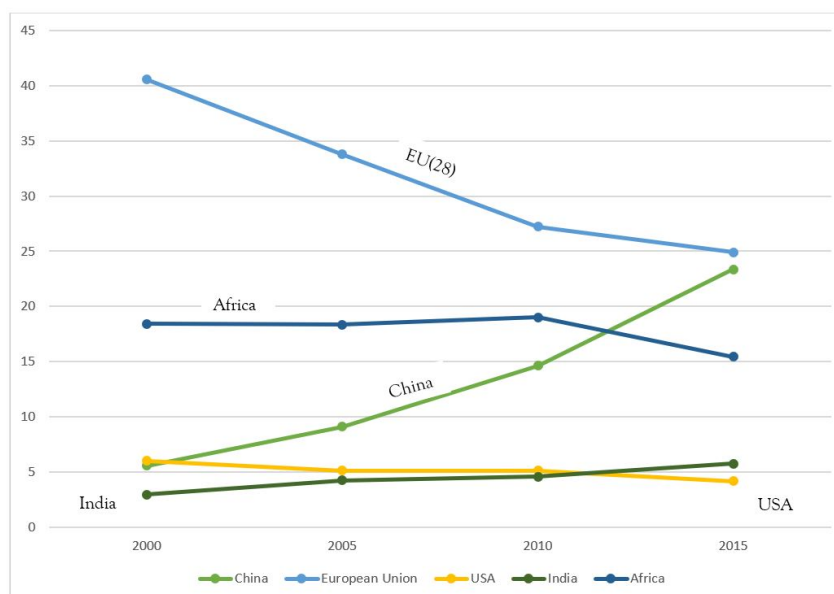


FIGURE 3.3 – Import share by Africa main partners (source : Own elaboration)

competition between high-tech products from China, the European Union, and the United States, and on the other hand, competition between Chinese and African low-tech products. The latter has been supported by the Forum on China-Africa Cooperation (FOCAC), which especially favors economic relations between these two partners, to such an extent that Chinese products have experienced a huge rise in the African market. Indeed, Figure 3.3 shows the evolution of the share of imports to the African continent from its main partners. China's share rose dramatically after 2000, followed by that of India, which is also a key partner of African countries. Former players experience a gradual decline over the same period; the fall of the European Union being the most drastic. Today, China and India are the first and second largest trading partners, respectively, of African countries with a trade share above that of all other single trade partners of the continent¹. However, the total volume traded between China and Africa is about three times that traded between India and Africa [Nowak, 2016] but the destination markets are approximately the same. In other words, the top ten African countries that trade with China are almost the same that trade with India. As shown in Figure 3.4, India



FIGURE 3.4 – Africa's trade balance with China and India (source : IMF, 2020)

is a net importer from Africa, while the opposite is true for China. Indeed, the figure reveals that Indo-African trade is often in deficit in favor of Africa while China has had a permanent trade surplus with Africa since 2000. Therefore, we deduce from all the above that to analyze the impact of the penetration of foreign products likely to compete with local products, it is more interesting to focus on Chinese products, given their strong penetration in the African market. But how?

The African economy, like any other economy, is generally based, on two pillars² : services and manufacturing. The latter was towards the end of the 18th century, the main engine of growth, development, and catch-up, argued [Szirmai, 2012]. He added that the manufacturing sector is important for development for several reasons including that (a) there is an empirical correlation between the degree of industrialization and per capita income in developing countries; (b) productivity is higher in the manufacturing sector than in the agricultural sector; (c) manufacturing is more dynamic than other sectors; and (d) developing countries with higher shares of manufacturing and lower shares of services grow faster than advanced service econo-

1. African Trade Report 2020, Afreximbank
<https://afr-corp-media-prod.s3-eu-west-1.amazonaws.com/afrexim/African-Trade-Report-2020.pdf>

2. plus agriculture in Africa

mies. The literature has shown that the countries which are now developed have gone through industrial development [Hallward-Driemeier, 2017] knowing that the manufacturing sector has the capacity to create dozens of jobs at a time. These revelations emphasize the relevance of focusing on the manufacturing sector. In Africa, there is a strong disparity between manufacturing sectors, from a “technological level” point of view. The manufacturing sector is at a very low level in low-income African countries, so Chinese penetration could be an obstacle to their emergence. However, it could also be an opportunity to invigorate once-dormant industries.

Until recently, many studies ([Autor, 2013]; [Dix-Carneiro, 2017]) have shown adverse effects of Chinese product penetration in developed countries on the local labor market and firm performance (sales, employment, productivity, etc.). In developing countries, particularly in Asia and Latin America, the harmful effects of Chinese product penetration have also been the subject of several studies ([Iacovone, 2013]; [Molina, 2017]; [Li, 2019]; [Blyde, 2020]; [Pierola, 2020]; [Rodriguez Chatruc, 2020]). Those results are relatively similar to those found in developed countries. China has left the same traces in all these countries, whatever their nature, i.e developed or not.

In this paper, we analyzed the impact of Chinese product penetration in African markets on firm sales and employment. To do this, we followed the [Dorn, 2020] approach and used a 2SLS estimator. Results showed that Chinese product penetration into African markets has a negative impact on firms' growth. However, this impact varies according to firms and countries' characteristics. Finally, we found that China's export to the same third countries as African countries reduced significantly African firms' sales but had no significant effect on their size. This impact is more important when the common market is in developed countries.

To our knowledge, this paper is the first to analyze the impact of Chinese product penetration in African markets on a sample of African countries at the firm level. The firm-level analysis allows us to take into account the disparities across countries, industries, and time to better understand the Chinese shock in Africa.

The rest of the paper is divided into five sections. After the literature review and the presentation of our methodology respectively, we describe our dataset and present our main variables. In the fourth section, we display the estimation results before checking their heterogeneity in the last main section.

2 Literature review

2.1 Possible effects of the Chinese shock

The Chinese shock has been a common subject of the economic literature in recent years. The manifestation of this shock has several aspects, namely (a) the growth of Chinese foreign direct investment (FDI) flows; (b) the increase in the total volume of Chinese debt and aid allocated to developing countries; and (c) the sharp increase in the total volume of trade between China and the rest of the world. According to the literature, these three manifestations of the Chinese shock are also observed on the African continent. In this paper, we focused on the trade side.

It appears from the literature that China mainly exports textiles, apparel, and machinery³ to Africa⁴. These goods can be used by both households and businesses; Chinese products serve as final consumption when they are consumed by households and as intermediate consumption or investment goods when they are consumed by companies. In the rest of our study, we will qualify the goods consumed directly by the consumers as *output* and those consumed by companies as *input*. The distinction between these two categories of goods allows us to explore all the mechanisms likely to explain the impacts of the Chinese shock on the manufacturing sector in Africa. A third dimension that also needs to be clarified is the *common third market*. The latter represents any market in which African and Chinese goods are simultaneously observed. Such a market may or may not be located on the African continent.

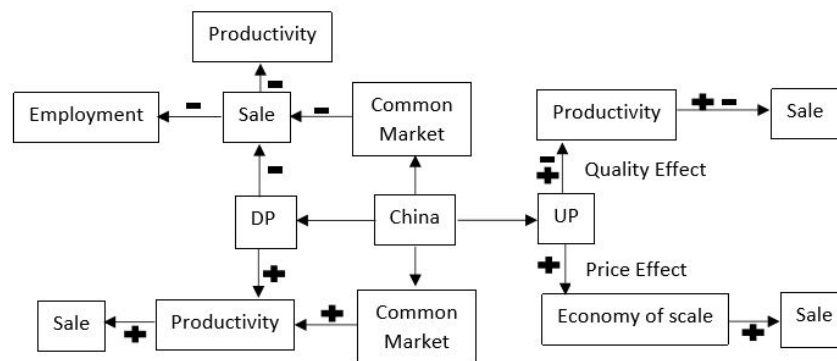


FIGURE 3.5 – Transmission Channels of China's Penetration Effects on Manufacturing (source : Own elaboration)

(Notes : UP : Upstream products ; DP : Downstream products)

Figure 3.5 illustrates the possible impacts of Chinese goods on the African market. These impacts are observed here on business characteristics such as sales, employment, and productivity which are fundamental for assessing socio-economic well-being and industrial emergence in a given economy.

2.1.1 Chinese penetration downstream of manufacturing plant : Domestic market

The penetration of (Chinese) outputs, also called here *Downstream products (DP)*, can exert downward pressure on local production. Indeed, Africa is known for its poverty rate and subsequent low purchasing power of its population. As such, competitive Chinese products are welcome regardless of their quality. The consumer's indifference to the quality of Chinese products is the main cause of the crowding out of local products. Thus, the drop in demand for local products leads to a drop in local supply, which is followed by a drop in productivity and manufacturing employment. The decline in productivity is obvious because the reduction in supply is not systematically accompanied by the reduction of inflexible inputs in the short term. As sales decline, company revenues will also decline, resulting in either lower wages or the dismissal of some employees. Chinese penetration can also be useful for African companies in the sense

3. Industrial Equipment, Electrical Appliances, Telecommunication Equipment, and Transport Vehicles

4. <https://www.oecd.org/swac/publications/38409391.pdf> // IMF (Direction of Trade Statistics), 2020

that it can encourage local companies, seeking to retain their market share, to invest in research and development in order to make innovations necessary to improve their productivity. This determines the leeway available to these companies in setting their selling price. The higher the productivity, the more they can reduce their price and thus maintain or increase their market share and sales. In the literature, several papers have focused on this problem, both in developed and developing countries; China does not go unnoticed in any market, be it European, American, Asian, or African. The research conducted on Chinese trade has led to similar conclusions, especially in developed countries. In the U.S. market, Chinese products have severely crowded out local ones. The corollary of this phenomenon is a drop in sales, an increase in unemployment, and a reduction in spending on research and development by companies ([Dorn, 2020], [Autor, 2013], [Acemoglu, 2016b]). In Europe, the situation is similar. For instance, in France, [Malgouyres, 2017] analyzed the impact of Chinese competition on employment and wages. He found that these two variables were negatively affected in both the manufacturing and non-manufacturing sectors. In the manufacturing sector, the local employment structure has been polarized. The distribution of wages is uniformly affected in the manufacturing sector, while the "non-tradable goods" sector experiences wage polarization, i.e. increased inequality at the top and decreased inequality at the bottom. Although overall wage inequality is on average unaffected, it has increased in response to trade shocks in areas where minimum wages are only weakly binding. For developing countries, the results are mixed. In Brazil, a study by [Rodriguez Chatruc, 2020] revealed a pro-competitive effect of Chinese competition on the productivity of factories, while employment appears to be negatively affected. While the impact appears to be homogeneous in Brazil and in Colombia, as shown by [Molina, 2017], this is not always the case elsewhere. In many other countries, Chinese penetration has had an impact that is not only heterogeneous across industries but also varies within the same industry according to the size and capital intensity of each firm. Thus, in countries where the overall effect is negative, it is not uncommon to find positive effects in some places. In general, large and capital-intensive firms tend to be more resilient to China's competition. This is the case, for instance, in El Salvador, where a study conducted by [Li, 2019] showed that Chinese penetration has negatively affected employment, productivity, and income of manufacturing firms overall, and especially those with fewer than 50 employees and low capital intensity. Relatively similar conclusions have been reported for Mexico [Blyde, 2020]. In Peru, firms reacted to increased competition from Chinese manufacturing goods mainly by altering their factor choices. For instance, smaller firms seem to have opted for reducing their demand for labor while larger firms seem to have adapted by deepening their capital requirements [Mercado, 2020]. Moreover, [Medina, 2017] had already shown that in the textile sector, the decline in profits for low-quality product segments is prompting some firms to raise the quality of their products to reallocate their production factors. This has resulted in an increase in the demand for employment in these companies.

Africa is no exception to these varied observations. Whether significant or insignificant, positive or negative, China has left its mark on the African manufacturing sector in a variety of ways across industries and countries. [Edwards, 2015] analyzed the impact of Chinese penetration on the manufacturing sector in South Africa. He found that Chinese competition has led to a

significant decline in sales and employment in manufacturing firms. According to the author, this is because competition is highly concentrated in labor-intensive firms, but also because this stiff competition has led to an increase in labor productivity. Africa, known for its low level of technology, could gain efficiency (improving Total Factor Productivity for instance) by duplicating the Chinese techniques hidden in the Chinese products that invade its market. This, however, is not possible if the workforce is not sufficiently trained for this purpose. For example, out of five African countries (Ghana, Kenya, Nigeria, South Africa, and Tanzania), [Elu, 2010] assess the effect of Chinese FDI and trade opening with China on firms' productivity. They find that neither has any significant effect. The result is the same for these countries' economic growth despite a large trade opening with China. However, this conclusion should be viewed with caution because the number of countries is small and the empirical techniques used have some limits. In the case of Kenya [Onjala, 2008] and Ghana [Tsikata, 2008], Chinese textiles have flooded the local market resulting in a loss of competitiveness for local industries and massive job losses.

2.1.2 Chinese penetration downstream of plant : Foreign market

Exporting companies can suffer a double setback in the face of the Chinese shock. In addition to domestic threats, they are also likely to face China in a third market. This common third market can be found in Africa, thus reducing intra-African trade, or outside the continent especially the developed countries whose market constitutes a popular destination for African products [Kowalski, 2006]. In the third market, competitive Chinese products, crowd out not only local products but also products from elsewhere, thus reducing the exports of several other countries. But as in the domestic market, these exporting companies can respond by adopting techniques necessary to improve their competitiveness both in the domestic market and abroad. They can also benefit from the support of their governments through policies that can facilitate the flow of their products to foreign markets. As a result, they would be less affected by any setbacks of the Chinese shock on the foreign market. We can cite, for instance, the cases of El Salvador [Li, 2019] and Peru [Mercado, 2020] where companies exporting to the same market as China have been differently affected. In El Salvador, competition in the common market led to an increase in the number of employees in charge of production in large firms, a decrease in productivity in medium-sized firms, and a reduction and increase of total income in low- and high-productivity firms respectively. In contrast to the previous case, Peruvian firms that shared an export market with China experienced a significant decline in hiring growth.

Africa, like many developing regions, is still under attack from China in the external market, despite the preferential treatment given to their exports. In American and European Union markets, China has severely crowded out low-cost products from Africa. Using disaggregated data, the empirical results of [Giovannetti, 2016] highlight these crowding-out effects at the sector, product, region, and market levels. Likewise, intra-African trade is currently less developed and seems to be shrinking more in the face of exports from China. The conflict arises when Chinese and African exports have the same destination in Africa. This phenomenon is more evident in the

textile sector⁵, where [Kaplinsky, 2006] showed that, between 2004 and 2005, Chinese exports to Africa increased at least 58% (and up to 112%) while those within Africa fell at least at 3% (and up to 45%). The manufacturing sector is also gradually fracturing, especially in countries where it is relatively developed. This is the case in Cameroon which, according to [Khan, 2008], experienced a drop of about 42% in its exports to other countries on the continent. In East Africa, [Onjala, 2008] shows that this loss is around 20% for Kenya. In the case of Mauritius, [Ancharaz, 2008] estimated that this collision of Chinese and African exports to Africa led to a reduction in the production of around 12.5%, the closure of 112 factories, and the loss of 25,000 jobs.

2.1.3 Chinese penetration upstream of companies

It is important to stress that the effects of Chinese penetration on African companies do not appear only downstream but also upstream. Indeed, China can give to companies a boost by providing them with less expensive inputs, defined as *upstream products (UP)*. In doing so, it can help them reduce their production costs and thus benefit from economy of scale (i.e price effect of inputs). However, this advantage is not systematic and could hide a disadvantage. At the beginning of China's rise, Chinese products were considered to be of low quality. If this were the case, inputs from China would negatively affect the productivity of companies and make them less competitive (quality effect of inputs). Unsuitability or inadequacy of inputs (intermediate goods and investment goods) to production conditions in Africa can be decisive in the efficiency of these inputs. African production facilities can be obsolete and potentially hazardous, making them more susceptible to the negative effects of poor-quality materials. Alternatively, one could hypothesize that companies lack the expertise to properly handle Chinese products. These different reasons can justify a probable negative impact of Chinese inputs on productivity and consequently on company sales. Very few studies have focused on the effects of Chinese inputs on the manufacturing sector of importing countries. Among them, some have found that Chinese inputs have no significant effect on firm sales ([Li, 2019], [Blyde, 2020]) while others have found negative effects ([Iacovone, 2013], [Mion, 2013]). According to the literature, far from being beneficial to firms, Chinese inputs aggravate the threat of Chinese outputs. Finally, China has also left mark on the informal sector. Thanks to cheaper and more accessible inputs, companies in this sector have transformed themselves by expanding and strengthening their capital stock. The corollary of all this is not only their transition to the formal sector but also an increase in the demand for labor and an improvement in productivity. For example, in Peru, [Pierola, 2020], revealed that as Chinese penetration increases, the demand for unskilled labor increases in the informal sector but their real wages decline.

2.2 China shock effects through domestic production network

So far, we have addressed the direct aspect of the impact of Chinese penetration on the domestic market. But we still have to discuss the indirect aspect, namely the impact on the

5. World Trade, Organization. (2006) International Trade Studies 2006. Geneva, Switzerland : WTO.

local production network, which stems from the diffusion of the direct effect along the production chain. When firms at the last stage of the production chain receive a positive or negative shock, it can trickle upstream to the input suppliers. Input suppliers are doubly impacted when they are also exposed to a direct shock. For example, this problem may arise when China exports both finished and semi-finished products that are used to manufacture finished goods to the same country. Figure 3.6 illustrates this phenomenon. Suppose this is the structure of the manufacturing sector in a given economy. The circles represent firms at different levels of the production chain. The arrows indicate that the products of the preceding firms serve as inputs for the following firms. Let us assume in our example a multi-product enterprise that serves two separate enterprises and then produces a variety of products. Thus, firms at the beginning of a production chain can be called, for instance, extractive firms in the sense that they directly handle raw materials in their raw state to obtain one or more products of low added value. The enterprises within the chain successively add value to the products whose final transformation will be carried out by the enterprises at the end of the production chain. The products thus obtained at the last stage are called finished products and are destined for final consumption by households. Even if the literature shows that China exports more goods for final consumption, its presence is nonetheless significant at the intermediate stages. When China gains market shares with goods ready for final consumption that are, at the same time, locally produced, a rivalry arises in the local market. As mentioned above, this competition can lead to a decrease or an increase in local production. Everything depends on the resilience and response capacity of the firms at the end of the production chain (WTO, 2022). To simplify the analysis, let us assume that China does not intervene in the intermediate stages. In this case, two extreme situations can arise and the consequences are trivial. Indeed, when all the firms in the last stage are negatively or positively affected, the intermediate firms are also respectively affected. But when there is heterogeneity in the impact, the extent of diffusion depends on the architecture of the manufacturing sector. For example, suppose that the sales of firms 9 and 10 fall while those of firm 11 rise. In this case, firms 9 and 10 would also reduce their demand for inputs, which would reduce the sales of firms 8, 5, and 1. Firm 11, on the other hand, would increase its demand for inputs, which would increase the sales of firms 7 and 4. The variation in inputs also extends to the labor factor and may also impact the capital factor in the medium or long term, which may fall or rise depending on the case. These phenomena have been highlighted by [Atalay, 2017] and [Di Giovanni, 2014]. [Carvalho, 2008] and [Acemoglu, 2012] find that idiosyncratic shocks can propagate through the production network and produce macroeconomic effects. Thus, the China shock does not only affect the directly exposed firms but spreads throughout the economy through their suppliers ([Acemoglu, 2016a], [Acemoglu, 2016b], [Pierce, 2016]). Returning to our illustration, the impact of any shock on firms 2, 3, and 6 is undetermined. For example, firm 6 supplies two firms, one of which is negatively impacted and the other positively impacted, with distinct inputs. In this case, the literature postulates that firm 6 would specialize in producing inputs for firm 11. However, other firms of the same type as 6 may specialize in supplying inputs to firms of type 10. This mechanism was highlighted by [Goya, 2021] who studied the effect of Chinese competition on the domestic production network in Chile. His results show that when

the demand for a good falls in the domestic market, this leads to a fall in the number of domestic firms producing inputs for that good. In particular, multi-product firms tend to reduce the number of varieties produced, as a result of lower demand.

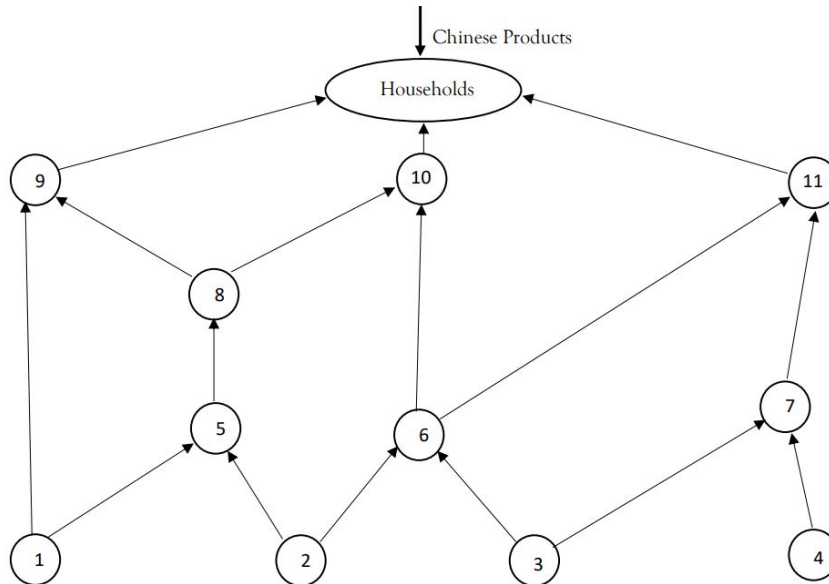


FIGURE 3.6 – Example of Domestic Production Network (source : Own elaboration)

On the other hand, we also see these same phenomena when the shock occurs on the external market, i.e. on exports. In the case of China, this is competition in common foreign markets, which may drive up or down the exports of firms at the bottom of the production chain. For example, [Ito, 2014] show that Japanese firms employ more workers when their customers' overseas sales increase. Similarly, [Huneus, 2018] find that the export demand shock induced by the Great Recession propagated backward through connected firms in the production network.

In sum, it is important to analyze both direct and indirect effects of China's penetration on a country's manufacturing sector, it is important to analyze both direct and indirect effects, especially with respect to factors of production when they are mobile within or across sectors. None of the studies on Africa have addressed the problem in all its dimensions, i.e., by looking at the impacts of China-Africa trade at the input and output levels separately. In the next section, we present models and methods that can help fill this gap.

3 Data and Empirical strategy and Some descriptive analysis

3.1 Data

We used three main sources of data. The firm-level data are taken from the "Enterprises Survey Data" (ESD) of the World Bank. They cover 28 African countries for different periods between 2001 and 2018 (see appendixes 1, 2, and 3). Data on most countries covers 2 or 3 years. Except for Cape Verde which joined after 2001 (the date of China's entry to the WTO), all other countries joined the multilateral trade institution in at least 1995. Even though Ethiopia has still

observer status, it has a strong trade relationship with China [GebreEgziabher, 2006]. Several pieces of information are available in this first dataset. The ESD enables us to distinguish two categories of firms : importing firms that import at least 10% of their inputs (see appendix 2) and non-importing firms for whom at least 90% of their inputs come from domestic markets (see appendix 3). Likewise, firms that export at least 10% of their production are exporters. A review of the data reveals that firms that use imported goods have a high level of partial foreign ownership. A stronger presence of foreign owners may perhaps facilitate the import of foreign inputs. In addition, the average number of employees in African importing firms is statistically higher than that in non-importing firms. This reveals that large companies in Africa tend to use more foreign products.

National input-output data available at the industry level is taken from EORA Database. While there is a convergence across the major Input-Output (IO) databases (EORA, EXIO-BASE, WIOD, GTAP, and OECD), Eora has the longest annual time series from 1970 to 2015 and also covers the largest number of countries. All factories are classified into eight industries⁶.

Bilateral trade Data from BACI⁷ of CEPII (Centre d'Études Prospectives et d'Informations Internationales) reports annual import values and quantities by product of 6-digits at the country-level. This information is available for 47 African countries⁸ until at least 2011. To conform with the EORA design, all imported goods have been grouped into seven industries. We have used the concordance file between *H0 codes* and *isic rev3 codes* downloaded from World Integrated Trade Solution (WITS) to convert H0 into the "isic rev3" codes. After that, we follow [Lenzen, 2013] approach to match "isic rev3 codes" to the EORA industry classification.

3.2 Empirical strategy

In this paper, we are seeking to measure the impact of the penetration of Chinese products on African firms. This analysis will focus on three dimensions : output, input, and third market level. These dimensions allow us to capture the Chinese effect on both upstream and downstream African firms.

In the literature, many firms' characteristics are used to analyze their growth. These are typical *assets, employment, market share, physical output, profit, and sales* ([Delmar, 1997], [Ardishvili, 1998]). Based on available data, we focused on two frequently used indicators of growth [Delmar, 1997], namely sales and employment growth. These two complementary indicators provide an overall measure of firms' growth ([Delmar, 2003], [Coad, 2009]). Indeed, the sales growth indicator provides information on short and long-run growth. But, unlike employment growth, it is correlated with economic market conditions, such as inflation and exchange rate variation, especially for exporting firms. Unlike sales growth, employment growth is not suitable for short-term analysis because the dismissal and recruitment of a worker tend to be a long-term decision process. [Delmar, 2003] shows that these two indicators may evolve in opposite

6. Food and beverages, textiles and wearing apparel, Wood and paper, Petroleum, chemical, and non-metallic mineral products, Metal products, Electrical and machinery, Transport equipment, and Other manufacturing

7. International Trade Database at the Product-Level.

8. The BACI Database does not provide data on Botswana, Comoros, Eswatini, Lesotho, Somalia, Namibia, and Sudan

directions. However, they are often correlated with other growth indicators. For example, when a firm increases its assets, its sales increase and the number of employees may also increase.

To assess the effect of Chinese penetration on African firms' growth, we followed [Dorn, 2020] who evaluated this effect on the US market innovation as measured by patent production. So our general model can be presented as the following equation :

$$\Delta Y_{ikj\tau} = \alpha_{\tau} + \beta \Delta CHN_Pen_{kj\tau} + \gamma_1 \Delta X_{kj\tau} + \gamma_2 Z_{jt_0} + \lambda_k + \mu_j + \rho_t + \Delta \epsilon_{ikj\tau} \quad (3.1)$$

where

$$\Delta Y_{ikj\tau} = \frac{100(Y_{ikjt_1} - Y_{ikjt_0})}{0.5(Y_{ikjt_1} + Y_{ikjt_0})} \quad (3.2)$$

$\Delta Y_{ikj\tau}$ represents the growth of sales or employment of firm i for industry k in country j over period $\tau = (t_0, t_1)$. Like the growth indicator, the measurement of growth has been the subject of controversy in the literature. There is still no consensus on this subject [Wong, 2005]. For the same growth indicator, different measurement methods can lead to different conclusions. Researchers have distinguished several techniques to measure firm growth quantitatively and qualitatively ([Coad, 2009]; [McKelvie, 2010]) : organic growth, creation of new firms, concentration of existing firms (mergers, acquisitions), and growth through innovation and diffusion of new products and processes [Delmar, 2003]. Quantitative analysis tends to be easier to conduct because it is less data-intensive than qualitative analysis, which requires fairly detailed data. Given that the data used in this analysis is less detailed, firm growth is measured as organic growth. There are two types of organic growth : absolute growth, which consists of calculating a simple difference in the growth indicator (here sales and employment), and relative growth, which examines the relative change in the indicator. The usual formula for assessing relative growth is to divide absolute growth by the initial (i.e., t_0) value of the growth indicator. In doing so, the former is biased in favor of large firms while the latter is biased in favor of small firms. Equation 2 addresses these problems by dividing the change of sales (respectively, employment) during t_0 and t_1 , by the firm's simple average of sales (respectively employment) during the same period. This formula is preferred to the usual formula for calculating the growth rate because it allows outliers to be taken into account ([Davis, 1992], [Aterido, 2010], [Haltiwanger, 2013] [Léon, 2020a], [Léon, 2020b]). One-off shocks can create a sharp rise or fall in output only at the beginning or end of the period. In such cases, we could see a boom or a bust in growth. For example, suppose we want to calculate the growth of firms between the year 2007, marked by a financial crisis, and the more or less stable year 2012. With the usual growth rate formula, we would obtain a very high growth rate that would not reflect the true performance of these firms. Similarly, outliers can also come from small and young firms [Fitzsimmons, 2005] even if Gibrat's law (much criticized in the literature) stipulates that a firm's growth is independent of its size [Gibrat, 1931]. Indeed, since small firms have low output and few employees, they can have higher growth rates ([Scherer, 1990]; [Almsafir, 2015]).

The main explanatory variable is $\Delta CHN_Pen_{kj\tau}$, the absolute growth of Chinese (output

or input) product penetrations in industry k in country j over τ . It is measured at the country level and by industry. Since China is not the only country that exports to Africa, other trading partners' products may compete with both domestic firms and Chinese products. If the penetration of these potential competitors is not included in the model, their effects would be captured by the coefficient β . We have retained as potential competitors, India and countries belonging to the same integration zone⁹ as the country j considered. Thus, the variable $\Delta X_{kj\tau}$ incorporates the growth of penetration of these competitors. We also added other control variables (Z_{jt_0}) in lagged period susceptible to influence the firm response to China penetration, such as *electricity access rate*.

Since the analysis integrates several countries, industry-specific dummy and country-specific dummy variables are included to take into account the unobservable and variable heterogeneities over time between industries (λ_k) and countries (μ_j). To account for circumstantial effects and global heterogeneity over time, we included a time dummy. This model probably could suffer from a major limitation. Indeed, when the China penetration changes slowly across time, this can lead to large standard errors for the associated coefficient. Fortunately here, there is a great gap between each observation year for most countries, therefore it is likely to have very large variations for our variables.

3.2.1 China's shock effect on downstream African firms : Output level analysis

All products locally produced are considered output. While some of these products are directly used by households, others can be used as input by others enterprises. The analysis of China's shock on downstream African firms does not require knowing "which product from which industry is used as input of a given industry". It only requires information on which product is produced by a given enterprise and what is the China penetration of this product. The literature suggests that Chinese product penetration can significantly reduce African firms market share ($\beta < 0$) but can also drive up the firm's sales ($\beta > 0$) if they respond to the competition by investing to become more efficient and resilient. To investigate the impact of Chinese penetration, we modified Equation 1 as follows :

$$\Delta Y_{ikj\tau} = \alpha_\tau + \beta \Delta CHN_Pen_out_{kj\tau} + \gamma_1 \Delta X_{kj\tau} + \gamma_2 Z_{jt_0} + \lambda_k + \mu_j + \rho_t + \Delta \epsilon_{ikj\tau} \quad (3.3)$$

While most variables remained the same, the variable $\Delta CHN_Pen_{kj\tau}$ is replaced with $\Delta CHN_Pen_out_{kj\tau}$, which measures the penetration of downstream products as follows ([Dorn, 2020])

$$\Delta CHN_Pen_out_{kj\tau} = \frac{M_{kjt_1}^{chn} - M_{kjt_0}^{chn}}{Prod_{kj2000} - X_{kj2000} + M_{kj2000}}$$

Where M_{kjt}^{chn} is the import from China in industry k , in country j at time t . The denominator measures the economic absorption in the year 2000. It is composed of the share of the industry k production used by a national economy which is the difference between production ($Prod_{kj2000}$)

9. Integration zone includes ECOWAS, SADC, COMESA among others

and export (X_{kj2000}) in industry k . The last term in the denominator represents the import (M_{kj2000}) from the rest of the world of industry k products. The year 2000 is chosen to reduce the endogeneity risk of the variable $CHN_Pen_out_{kjt}$. The underlying assumption is a country's production in any industry could not have been disturbed by Chinese penetration given that China's trade opening began at the end of 2001.

Endogeneity stems from the Chinese penetration variable, and the error term $\Delta\epsilon_{ijt}$. Indeed, positive or negative shocks on domestic demand or the supply side of firms might cause endogeneity. A positive shock on demand would abruptly drive it upwards and downwards otherwise. Thus, a sudden increase in demand from local consumers will draw on both local production and imports. This is also the case for a negative shock on domestic demand; it would lead to a drop in local supply and a drop in imports. As for the supply shock, there is a problem of reverse causality. For example, a failure of the electricity network leading to untimely load shedding could reduce domestic firms' productivity and ultimately their production supply [Cole, 2018], which would reduce their competitiveness. This exogenous phenomenon would favor the penetration growth of Chinese products, which are very competitive. In the same way, a positive shock on the supply side, such as a tax exemption on the import of physical capital (e.g. equipment or machinery) would encourage business investment and therefore generate an increase in the productivity of local companies. This increase in productivity would strengthen the competitiveness of local products against imports, reducing the Chinese penetration growth.

Finally, many African countries (mainly from the Sahel) face insecurity and terrorism which can affect both national business climate and trade with the rest of the world. Unfortunately, a measure of national security for all African countries and years for analysis are not available¹⁰. The absence of this variable in the model could be a source of endogeneity and thus a further threat to the consistency of the β coefficient. For these various reasons, the variable $CHN_Pen_out_{kjt}$ is likely to be endogenous. In order to correct this endogeneity problem and in accordance with our data structure, we opted for the instrumentation method.

As a reminder, an instrument must respect two principal conditions to justify its validity. Firstly, there must be a strong causal relationship between the endogenous variable and the instrument, conditional to any control variable of the main model. The second condition, the "exclusion hypothesis", stipulates that the instrument must not have a causal relationship with the dependent variable (here, firm sales and employment) without passing by the endogenous variable. To achieve this, we follow [Autor, 2013]. The authors analyze the effect of rising Chinese import competition between 1990 and 2007 on US local labor markets. They use *other high-income countries imports* from China to instrument US imports from China. In this study, we instrument each African country's imports from China by using other low-income countries' imports from China.

According to the World Bank classification, we have collected all (non-African) countries belonging to low and intermediate-income categories. In order for the instrument to respect the exclusion hypothesis, we then proceeded to keep only those countries that have no economic link

10. The World Bank has constructed an indicator that provides information on the level of national security, but this information is not available either for all countries or for all years

or, at most, a very weak economic link with African countries. After removing those countries for which all trade data are not available on BACI, only ten countries remained : Cambodia, El Salvador, Honduras, Lao PDR, Moldova, Mongolia, Myanmar, Nepal, Nicaragua, and Papua New Guinea. Since not all African countries are economically similar, it would be incorrect to assume that China will penetrate their domestic markets in a similar way and assign the same values for the instrument. While some countries have experienced strong growth in Chinese penetration, others have shown a recession. To meet this requirement, we assign each African country in the sample with a country or set of countries belonging to the ten (non-African) countries selected. Most variables used for this association are taken from the WDI database. The sea distance between China and each country is taken from the CERDI-SeaDistance Database¹¹ and calculated by [Bertoli, 2016]. Applying the principal component analysis (PCA), we went from twelve variables¹² to four variables. The latter represents the first four factor axes obtained after PCA. These account for about 80% of the total information contained in the initial 12 variables. Finally, we performed a hierarchical bottom-up classification based on these four variables. The analysis of the dendrogram (Appendix 4) shows a division into three classes. Each of these classes includes corresponding African and non-African countries. Thus, all African countries in the same group will have the same values for the instrument. The instrument variable is defined as follows :

$$\Delta CHN_Pen_out_{kj\tau}^{G_h} = \frac{1}{n_h} \sum_j \frac{M_{kjt_1}^{chn} - M_{kjt_0}^{chn}}{Prod_{kj2000} - X_{kj2000} + M_{kj2000}} * 1_{G_h}$$

where G_h ($h \in \{1, 2, 3\}$) is the group h to which the non-African country j belongs. It includes a total of n_h non-African countries.

The instrument respects the "exclusion criteria" because it is not linked with the dependent variable. As there are no tangible economic relations between African countries and those which contributed to the construction of our instrument, Chinese penetration in the latter will have no significant impact on the performance of African companies. However, Chinese penetrations in these two categories of countries are very correlated because they are linked by the same cause i.e the productivity gains which are internal to China and do not depend on the global economy.

3.2.2 China's shock effect on upstream African firm : Input level analysis

As trade openness profits both firms and consumers to get cheap inputs and final products, respectively, as China's penetration does similar. China's import penetration would allow African companies to acquire cheaper intermediate inputs and thus reduce their production costs. The literature showed that following trade liberalization, companies that use imported inputs tend to be slightly more resilient to foreign competition ([Altomonte, 2014], [Amiti, 2007]). This

11. <https://zenodo.org/record/46822.X9PPithKg2y>

12. Access to electricity; rural (% of rural population); Access to electricity, urban (% of urban population); GDP per capita (constant 2010 US\$); Final consumption expenditure (% of GDP); Imports of goods and services (% of GDP); Oil rents (% of GDP); Total natural resources rents (% of GDP); Manufacturing, value added (% of GDP); GDP per capita, PPP (constant 2017 international \$); Exports of goods and services (% of GDP); Urban population (% of the total population) and sea distance between China and each country

resilience is due to the fact that not only are the prices of inputs affordable but also because the quality improves under the effect of competition. The Chinese case could be different because, at the start of its trade openness, its technological level was relatively low compared to that of developed countries. The low price of its products was mainly explained by its relatively high labor productivity. As [Blyde, 2020], we follow [Mion, 2013] and [Acemoglu, 2016b]. The former constructs plant measures for offshored inputs from China while the latter constructs upstream industry measures of Chinese import penetration using input-output linkages. Due to the absence of detailed information on the origin of the inputs imported by each company, we computed the offshored inputs from China at the industry level, as follows :

$$OFF_{kjt} = \frac{Import_{kjt}^{chn}}{Production_{kjt}} \quad (3.4)$$

where $Import_{kjt}^{chn}$ is the import from China to country j in industry k at time t while $Production_{kjt}$ is the total production of country j in sector k at time t . To address a potential endogeneity concern related to this measure, [Mion, 2013] used the exchange rate as an instrument, based on the idea that movements in the exchange rate are mainly driven by financial and macroeconomic determinants. This exchange rate is weighted by the share of China's input in the total input used by the firm. The movement of the exchange rate should have a large impact on firms using only inputs from China. Given that this paper considers several countries, this instrument can not be used because all African countries do not use the same currency. The order of magnitude of the different exchange rates would give absolutely no meaningful information in the aggregate. The other alternative proposed by [Acemoglu, 2016b] measures input penetration at industry level, as follows :

$$CHN_IP_{kjt} = \sum_r \frac{U_{rkt}}{\sum_r U_{rkt}} CHN_Pen_out_{rjt} \quad (3.5)$$

where U_{rkt} is the value of "upstream" industry r used by industry k at time t , and $CHN_Pen_out_{rjt}$ is the import penetration from China in industry r at time t . This measure of input penetration consists of a weighted average of the import penetrations in all the industries that provide inputs to industry k with weights based on input-output linkages. However, in the EORA (input-output) database, the imported inputs are not broken down by industry, so it is impossible to know, in total, which part comes from which industry. The WIOD database, on the other hand, provides fairly detailed information on the origin and industry of each input used by another industry. Unfortunately, this is only available for the (28) countries of the European Union and other (15) large countries around the world. Among these countries are some developing countries including India which can be technologically close to African countries. Therefore, we use

the technical coefficients (TC¹³) of India for African countries¹⁴.

This approach encompasses several dimensions of Chinese competition at the input level. It not only takes into account the fact that companies import inputs from China but, it also encompasses the competitive effect that this could generate at the local input market [Blyde, 2020]. However, this situation leads to ambivalence in the interpretation of this variable because a strong penetration of Chinese inputs can exert downward pressure on local prices so that firms that do not import from China will ultimately benefit even in sourcing from the domestic market. Unfortunately, we cannot distinguish these two effects. To correct the endogeneity of this variable, we proceeded as previously by constructing [Autor, 2013]’s instrument.

3.2.3 China’s shock effect on African firm through the third market

Competition between China and African businesses not only takes place in the domestic market, as discussed above but also in the foreign market. That happens when Chinese firms and African companies export to the same market. This effect has been widely analyzed in the literature, and the results are mixed. Some studies report a negative effect (i.e crowding out of exports from African companies). Other studies find a pro-competitive effect, whereby competition with Chinese firms in internal markets leads African firms to improve their productivity to remain internationally competitive. While several methods exist in the literature to analyze this phenomenon, in particular through the calculation of Chinese penetration on the third market, we follow [Blyde, 2020] who studied the case of Mexico and consider the United States as its main market since the United States represents around 90% of its exports. Then they used Chinese penetration in the US market to examine the effect of Chinese penetration in the common market on Mexican firms. In the BACI database, we identified 209 common markets for African countries (taken as a whole) and China out of international markets. Among these common markets, only the main partners (with the obvious exception of China) were retained. These include the countries of the European Union, the USA, India, and Africa itself. Moreover, [Balioune-Lutz, 2011] finds that Africa’s exports to China have, overall, no effect on Africa’s economic growth. Exporting to the OECD market is found to have a U-shaped effect with ultimately a positive effect on economic growth. In line with [Balioune-Lutz, 2011], we distinguish two types of markets : a *developing market* made up of African countries and India and a *developed market* made up of the European Union and the USA.

13. The technical coefficient is computed as follows :

$$TC_{rk} = \frac{U_{rkt}}{\sum_r U_{rkt}}$$

where U_{rkt} is the amount of input that industry k buys from industry r

14. The technical coefficients of India are also used as a proxy for the other ten countries selected for the instrument variable.

$$\Delta Y_{ikj\tau} = \alpha_{\tau} + \beta \Delta CHN_Pen_out_{kj\tau} + \sum_l \theta_{1l} (\Delta CHN_Pen_CM_{kl\tau} * Exporter_{ikjt_0}) + \quad (3.6)$$

$$\theta_2 Exporter_{ikjt_0} + \gamma_1 \Delta X_{kj\tau} + \gamma_2 Z_{jt_0} + \lambda_k + \mu_j + \rho_t + \Delta \epsilon_{ikj\tau}$$

where

- $\Delta Y_{ikj\tau}$ is the growth of firm i , in industry k and country j over period τ

-

$$CHN_Pen_CM_{kl\tau} = \frac{M_{klt_1}^{chn} - M_{klt_0}^{chn}}{Prod_{kl2000} - X_{kl2000} + M_{kl2000}}$$

$\Delta CHN_Pen_CM_{kl\tau}$ is China penetration on common market l in industry k over period τ

- $l \in \{\text{developing market (Africa\&India)}; \text{developed market (European-Union\&USA)}\}$,

- θ_{1l} is the parameter of interaction term. A positive sign means greater Chinese product penetration on the common market l more the exporting firm's growth increases on average.

Since penetration is measured at the sector level and only exporting companies can be affected by the impact of common markets, this variable is crossed with the exporting status of the company at the beginning of the period. The variable $Exporter_{ikjt_0}$ is a binary variable taking the value of 1 if the firm i in industry k , country j at time t_0 is an exporter and 0 otherwise. We do not need to instrument these variables because a (positive or negative) shock on demand or supply, in one of the countries forming the common markets, is insufficient to explain the penetration of China or any African country to the common market group considered.

3.3 Some descriptive analysis

The next figure shows the output penetrations¹⁵ for five African countries : Egypt, Ethiopia, South Africa, Tanzania, and Togo over the period 2000-2018. It shows that there is great diversity in the dynamics of Chinese penetration over time and across countries.

15. The output penetration is defined as

$$CHN_Pen_out_{kjt} = \frac{M_{kjt} * 100}{Prod_{kj2000} - X_{kj2000} + M_{kj2000}}$$

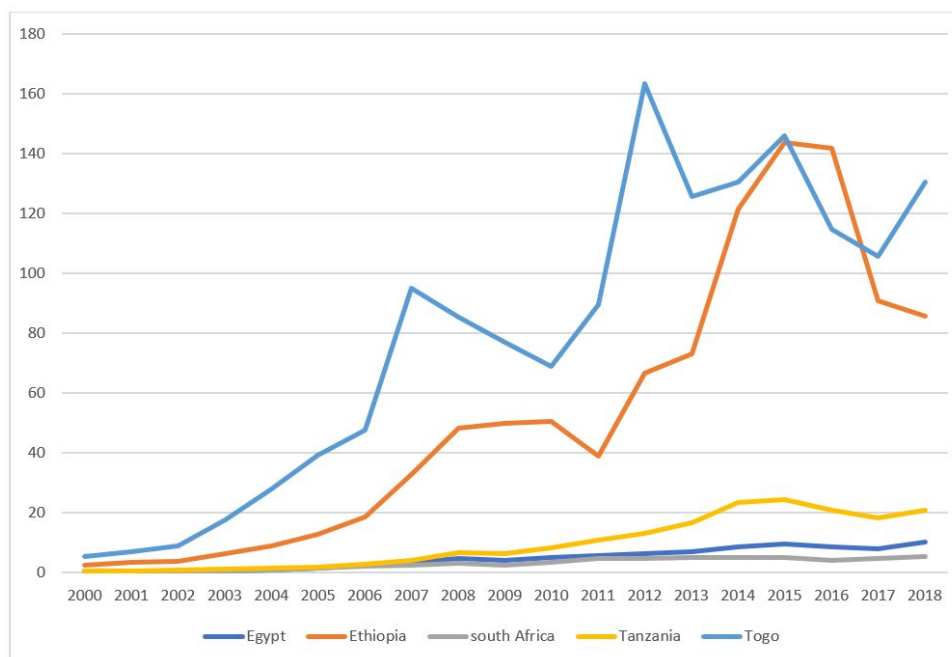


FIGURE 3.7 – Evolution of China's penetration (%) across selected African countries (source : Own elaboration)

The layout of the curves reveals that low-income countries have a strong acceleration in Chinese penetration in their relevant markets. Even though high-income African countries have experienced this shock gradually, they nonetheless represent the largest importers of Chinese products as shown by [Nowak, 2016]. The strong penetration of China in low-income countries can be justified by the weak development of their manufacturing sector. Therefore, there is a large gap between domestic demand and production, which would be filled by Chinese products at very affordable prices compared to Western products. The cost of transport faced by each of these countries is another relevant factor. Indeed, a high cost of transport could constitute a real obstacle to importing from China and could explain the divergence of the exposure of each to the Chinese shock within the sub-sample of low-income countries in Africa. For example, two poor countries with similar economies will likely face different transport costs if one country is landlocked and the other is not. Several other characteristics such as population growth, economic growth, and trade policies are likely to explain the evolution of Chinese penetration in each country.

Like the country level, there is also heterogeneity in China's penetration at the industry level. In Figure 3.8, the penetration by industry is shown for the previous countries (except Tanzania). This figure shows that not all sectors are exposed (downstream) in a similar way to the Chinese shock. The textile sector is the most penetrated.

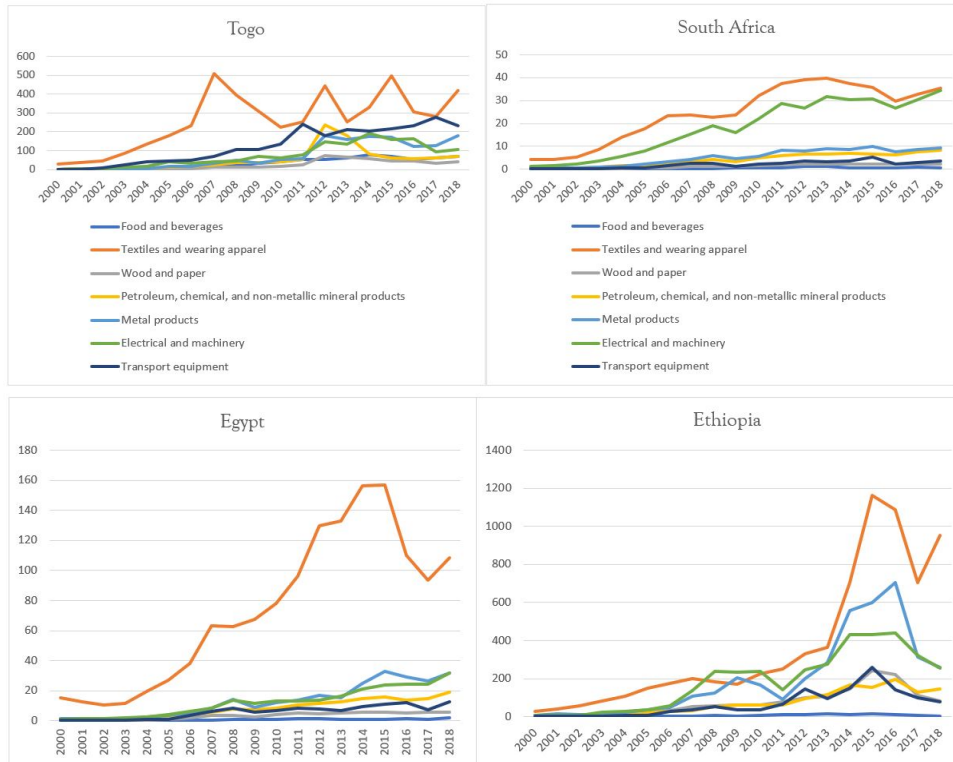


FIGURE 3.8 – China output penetration (%) : Time variation within countries across industries (source : Own elaboration)

of the four countries and probably in most African countries according to the literature. In South Africa, the "Electrical and Machinery" sector is the second most penetrated. As for the other countries, it is difficult to prioritize penetrations at the level of industries. The heterogeneity of Chinese product penetration can also be explained by the heterogeneity of customs tariffs for corresponding industries. Indeed, foreign products are not subject to the same taxes. It is therefore possible that customs taxes are a barrier to Chinese penetration in certain industries. Another argument that could explain this divergence is that not all industries have the same level of development within the same country. Some industries are more advanced than others and are able to efficiently meet a very high proportion of local demand. In other words, the greater the deficit between local production and local demand, the more China's penetration is likely to be high.

Although the most recent year of data is 2015, the calculation of input penetration can be extended up to 2018 thanks to the [Acemoglu, 2016b]'s approach¹⁶. Figure 3.9 illustrates the input penetrations by industry for four African countries between 2000 and 2018.

16. The input penetration is computed as follows

$$CHN_IP_{kjt} = \sum_r \frac{U_{rkjt}}{\sum_r U_{rkjt}} * CHN_Pen_out_{rjt}$$

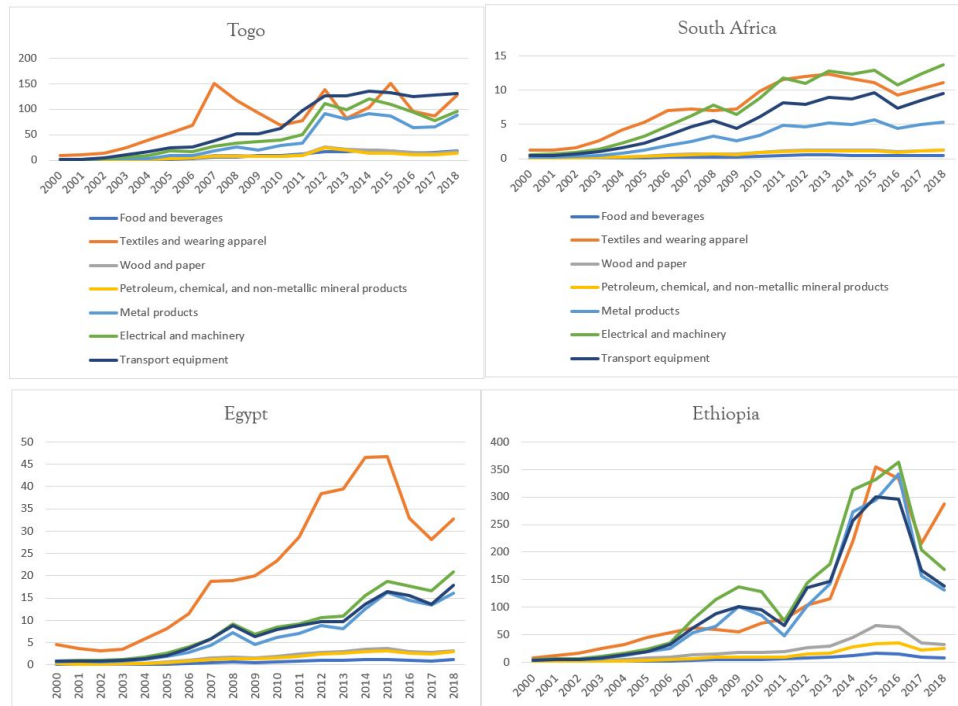


FIGURE 3.9 – China input penetration (%) : Time variation within countries across sectors (source : Own elaboration)

The figure shows that not only does input penetration vary over time, but it also varies by industry. In other words, not all upstream industries are exposed to the Chinese shock, in the same way. If we consider Egypt, the textile industry benefits the most from Chinese inputs. Ethiopia presents a slight peculiarity. There is an almost perfect correlation between Chinese input penetrations in certain industries. Nevertheless, by observing the structure of penetrations in the four countries, we see that there is a strong diversity both at the industry level and at the country level.

4 Estimation results

This section presents the estimation results of the evaluation of the effects of Chinese penetration through outputs ($\Delta ChinaPenOut$), inputs ($\Delta ChinaPenInp$), and common external markets on sales and employment. As discussed above, we have also added the penetration of India ($\Delta IndPen$) and that of the member countries of the same free trade area ($\Delta FTAPen$). The two types of common external markets namely developed ($\Delta chnX_EUSA_cm$) and developing ($\Delta chnX_AI_cm$) markets are also included in the models. These are interacted with the exporter status (Exporter) of each firm. At the country level, we have used the variable *electricity access rate*¹⁷ because the availability of electricity is essential for the proper functioning of a company. Given the small number of observations in our sample, we used groups of countries and times instead of dummy countries and dummy times. We distinguished five groups of countries (Ecowas, ECCAS, EAC, AMU, and SADC) according to their geographical position. The

17. The variable *electricity access rate* is a categorical variable

underlying assumption is that geographically close countries, linked diplomatically and economically, would undergo common systemic shocks or would be affected by economic shocks jointly. With regard to time, we have distinguished three periods, namely 2001-2006; 2007-2008, and 2008-2018. This division of time is based on the assumption that there is a certain continuity and monotony in time before and after the financial crisis of 2007-2008.

4.1 China's penetration effect on firm sales

While the penetration of Chinese outputs on these markets could be a threat to African firms, Chinese input penetration on the domestic market could be, an opportunity thanks to the economies of scale that they could generate. Table 3.1 presents the results of the empirical analysis of the downstream and upstream effects of Chinese penetration on African firms' sales. Columns [1] to [4] report the results of the downstream effects, while columns [5] and [6] display the results of the upstream effects. Columns [7] to [9] report the results for both downstream and upstream effects. For each model specification, the common external market variables are taken into account except for specifications 5 and 6. All model specifications include industry, country, time-fixed effects, and the electricity dummy variable.

Overall, we retain from the first sequence that the penetration of Chinese outputs significantly reduces the sales of African companies, which confirms our initial hypothesis. The OLS model also shows a very statistically significant but smaller effect than the 2SLS estimates. We also see that controlling for the penetration of potential competitors (faced by China in the African market) namely India and countries of the same FTA (model 2), reduces the effect of the Chinese shock, in absolute value. With regard to common external markets, competition is fiercer in developed countries.

When we consider the following sequence (that of the inputs), the OLS model indicates a negative but not significant effect while the 2SLS model reports a significant decrease in domestic sales following the penetration of Chinese inputs. This result is counterintuitive and runs counter to our hypothesis. This finding can be explained if African firms lack the expertise to better utilize Chinese inputs. Inadequate Chinese inputs to African firms' working conditions could also explain this result.

The last model specification, which incorporates both types of products (input and output) at the same time, presents results that go in the same direction as the previous ones. However, the upstream effect is not statistically significant while retaining its sign knowing that the significance of the outputs has dropped considerably. This may be due to the collinearity between the two Chinese penetration variables. Consequently, in the end, we maintain that the Chinese shock constitutes a real threat to African companies both on the output side and on the input side. These results are in line with those found in the literature.

TABLE 3.1 – Effect of China penetration on African domestic firms' sales

VARIABLES	Downstream effect				Upstream effect		Both effects		
	[1]-OLS	[2]-IV	[3]-IV	[4]-IV	[5]-OLS	[6]-IV	[7]-IV	[8]-IV	[9]-IV
$\Delta ChinaPenOut$	-0.315*** (.059)	-6.876** (2.905)	-4.350*** (1.349)	-3.757*** (1.210)			-5.636* (3.425)	-4.193** (1.887)	-3.469* (1.837)
$\Delta ChinaPenInp$					-0.158 (.115)	-1.659*** (0.303)	-0.514 (0.684)	-0.234 (0.689)	-0.345 (0.710)
$\Delta FTAPen$			-1.378*** (0.462)	-1.190*** (0.436)				-1.492** (0.637)	-1.253** (0.620)
$\Delta IndPen$			-4.413*** (1.027)	-3.975*** (0.983)				-3.655* (2.080)	-3.093 (2.173)
$\Delta chnX_AI_cm * Exp$				-6.935*** (2.676)					-9.068** (3.706)
$\Delta chnX_EUSA_cm * Exp$				-32.667*** (6.797)					-26.62*** (9.075)
Exporter				36.78*** (8.340)					42.02*** (9.102)
Constant	-94.505*** (10.037)	72.83 (48.87)	34.45 (28.70)	13.10 (27.96)	-100.77*** (8.575)	-107.3*** (9.396)	62.13 (88.67)	42.36 (58.74)	14.73 (61.17)
Observations	3,651	3,985	3,868	3,651	3,830	3,830	3,830	3,713	3,503
IV F-stat		26.30	73.27	70		770.5	4.666	15.50	12.51
Wooldridge(p_endog)		2.88e-10	6.46e-10	1.32e-07		3.03e-09	0	0	4.78e-09

Notes : All models include a dummy for country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[and [80,100])
Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. IV refers to 2SLS estimator with $\Delta ChinaPenOut$ and $\Delta ChinaPenInp$ are instrumented by their correspondent instruments.

4.2 China penetration effect on firm size

Industry in Africa is slowly expanding even though the sector remains dependent on an abundant labor force and still struggles to adopt advanced technologies. African firms are still specialized in the production of labor-intensive goods. In that context, a negative or positive shock on their sales is likely to impact employment. Table 3.2 presents the results of the evaluation of the effect of the Chinese shock on African firm size captured by its number of employees.

TABLE 3.2 – Effect of China penetration on African firms' employment

VARIABLES	OLS	[1]-IV	[2]-IV	[3]-IV
$\Delta ChinaPenOut$.241*** (.049)	-2.691* (1.629)	-1.555** (0.768)	-1.446** (0.729)
$\Delta FTAPen$.207 (.181)		-0.350 (0.255)	-0.241 (0.246)
$\Delta IndPen$	-.004 (.190)		-1.524*** (0.588)	-1.513*** (0.578)
$\Delta chnX_AI_cm * Exp$	-.321 (1.253)			-2.503 (1.606)
$\Delta chnX_EUSA_cm * Exp$	-9.942** (4.116)			-6.123 (4.448)
Exporter	-4.161 (4.393)			-3.024 (4.592)
Constant	-7.631 (6.025)	54.77** (27.21)	38.41** (16.83)	38.28** (16.59)
Observations	4,056	4,391	4,269	4,034
IV F-stat		18.02	55.46	54.87
Wooldridge(p_endog)		0.000997	0.000606	0.00107

Notes : All models include a dummy for country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

The same model specification is used as in the case of the firms' sales analysis, namely industry, country, and time fixed effects, China's penetration, other competing countries, and common markets are included. The results are consistent with our assumptions except in the OLS model. Indeed, the latter shows a positive and statistically significant effect of Chinese penetration on firms' size, but as soon as we correct for endogeneity by switching to 2SLS models, this coefficient becomes negative and statistically significant. As for the effects via the channel of the common external markets, no statistically significant impact on firms' employment appears neither on the side of the developing countries nor on the side of the developed countries. In conclusion, Chinese competition has been found to have a negative impact on manufacturing jobs in Africa.

5 Robustness Check

5.1 Alternative Model

In the previous models, we considered the dummy countries, industries, and time separately. This means that the unobservables across countries, industries, or over time are the same. However, this is not necessarily true. For example, the "wood and paper" industries in Benin and Morocco are likely to be different in terms of development level. These two industries are also not subject to the same political, economic, and social shocks. The same goes for other countries and industries. We repeated the first three model specification in Table 3.1 to include

the interaction terms of country, industry, and time to take into account these specificities.

TABLE 3.3 – China’s penetration effects on firms’ sales (alternative approaches)

VARIABLES	Sale Growth(t_0, t_1)			Sale Growth($t, t-2$)					
	IV			IV			FE-IV		
$\Delta ChinaPenOut$	-8.096**	-10.27**	-4.194***						
	(3.577)	(4.735)	(0.786)						
$\Delta FTAPen$	-1.105	-1.541**	1.549**						
	(0.760)	(0.780)	(0.649)						
$\Delta IndPen$	-9.482***	-10.77***	-6.807***						
	(3.370)	(4.085)	(1.052)						
$\Delta chnX_AI_cm * Exp$	-19.94***	-19.91***	-6.697**						
	(7.587)	(7.649)	(2.690)						
$\Delta chnX_EUSA_cm * Exp$	-3.947	-14.28	-18.71**						
	(15.70)	(13.07)	(8.742)						
Exporter	43.56***	49.19***	27.26***	-3.224	40.09	-2.243	-12.658*	-13.179	-9.578
	(10.83)	(11.82)	(8.236)	-5.092	(112.3)	(3.369)	7.039	(7.036)	(7.077)
$\Delta ChinaPenOut(t, t-2)$				-1.842	11.36	-1.482***	-0.673	-0.591	-1.239***
				(1.154)	(36.23)	(0.343)	(0.551)	(0.578)	(0.476)
$\Delta FTAPen(t, t-2)$				-0.0716	-0.0985	0.113	-0.083	-0.099	-0.18
				(0.0719)	(0.255)	(0.0922)	(0.114)	(0.112)	(0.116)
$\Delta IndPen(t, t-2)$				-0.680	8.051	-0.179	-0.243	-0.291	-1.599***
				(0.818)	(23.06)	(0.308)	(0.427)	(0.422)	(0.572)
$Exp * \Delta chnX_EUSA_cm(t, t-2)$				3.509	-41.59	-2.336	-12.162	-13.877	-15.066*
				(7.808)	(102.7)	(4.555)	(9.183)	(8.931)	(8.966)
$Exp * \Delta chnX_AI_cm(t, t-2)$				1.808	-20.18	1.950	-0.618	-0.445	0.482
				(2.340)	(59.31)	(1.242)	(1.741)	(1.824)	(1,850)
Constant	39.73	113.9**	-26.93**	-7.340	-139.3	25.46***	-28,918	-37,368*	1,717
	(43.62)	(56.92)	(12.72)	(15.96)	(444.9)	(5.340)	22.716	(16,849)	(16,944)
Observations	3,651	3,651	3,651	3,908	3,908	3,908	3,908	3,908	3,908
R-squared				0.112		0.210	0.270	0.283	0.299
IV F-stat	17.05	11.45	305.5	14.84	0.481	178.9	84.28	56.97	41.85
Industry*Country	X			X			X		
Industry*Year		X			X			X	
Country*Industry*Year			X			X			X

Notes : All models include electricity variable (<20 ; $[20,40[$; $[40,60[$; $[60,80[$ and $[80,100]$); Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; IV refers to 2sls estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument while FE refers to Fixed-Effects estimator

The results shown in Table 3.3 are relatively similar to the benchmark results. The impact of Chinese penetration on sales growth remains negative and statistically significant. As for competition in foreign markets, the magnitude of the impact on developed markets is always greater than that on developing markets. In addition, in order to verify the robustness of the results, we follow [Chauvet, 2018] and reestimate the previous models using 2-year lagged observations. We used the same method of calculation to evaluate the growth over the period $[t-3, t-1]$. All the other variables are also recalculated over the same period¹⁸. To these variables, we applied two methods, the instrumental variable method and the within method (Fixed effects) combined with that of the instrumental variable. The results remain qualitatively similar. However, the coefficient of the variable of interest is only statistically significant when the interaction term of country, industry, and time, highlighting the importance of crossing unobservable heterogeneities in order to take into account local and temporary specificities.

18. The variable *Exporter* represents the exporting status of the last period ($t-1$) contrary to the previous cases where it represented the exporting status at the first period t_0

5.2 Instrumentation of India's penetration

In all the estimation models, the effect of India's penetration is close to or often greater than that of China. This situation seems paradoxical given that the growth of Chinese penetration and China's import share are greater than that of India. The larger estimated effect of Indian penetration may be due to endogeneity. To address this risk, we instrumented India's penetration using [Autor, 2013] approach applied similarly to the case of China. The results of this analysis, shown in appendix 5, confirm our assertion. While other variables conserve their sign and significance, the coefficient of India's penetration is still negative but no longer statistically significant. We, therefore, deduce that in all the previous and the next model specifications the coefficient of Indian penetration should be interpreted with caution. However, the latter remains a relevant control variable in these models.

Finally, note that our data show a very high attrition rate. If this is not corrected, it can introduce an upward or downward bias in the estimates. Indeed, the disappearance of certain companies in the sample in the second period or later may be due to an exit from the market or a voluntary non-inclusion for reasons of financing (as was the case for some companies in the sample). [Chauvet, 2018] who worked on a similar sample¹⁹, showed that this attrition had a negligible impact on the estimates.

6 Heterogeneity Analysis

6.1 China's penetration effect on sales according to firm characteristics

While one of the key benefits of free trade is low-cost access to finished and semi-finished goods by consumers and businesses respectively, one should not lose sight of its potential adverse effects on nascent businesses ([Shafaeddin, 2005]). In the worst-case scenario, the latter are sometimes doomed to leave the market. No less important is the case of small businesses. They are often less capital intensive and are therefore easy prey to the penetration of foreign products. A 5-year-old firm is defined as young while a firm exceeding the median size of all firms in the sample, namely 30, is defined as large.

In Table 3.4, the model specifications 2,3 and 4 from Table 3.1 are repeated on different sub-samples. The results show that there is a statistically significant and negative impact of the penetration of Chinese products (outputs) on less than 5 years old companies. When we estimate the same models on the sub-sample of firms that are 10 years older, the estimated impact turns positive but statistically insignificant in the three model specifications. These results suggest that young companies are particularly exposed to China's import competition.

The analysis of the firms' size shows that small African firms experienced a drop in sales as a result of the penetration of Chinese products into their markets. Conversely, Chinese penetration leads to a significant increase in large African firms. Large companies are often old companies ([Sleuwaegen, 2002], [Shanmugam, 2002]) with experiences that allow them to adapt to all the vagaries that occur in their markets. Large companies have more access to financial markets

19. Their sample also incorporates some African companies featured in our data

than smaller ones [Wang, 2016] and can therefore secure loans necessary to challenge their competitors.

TABLE 3.4 – Effect of Chinese penetration on African firms by age and company size

	[1]-IV	[2]-IV	[3]-IV
age<5years	-1.550** (0.622)	-1.139*** (0.369)	-1.239*** (0.370)
Observations	516	501	489
age>10years	26.17 (31.48)	38,932 (7.961e+07)	161.8 (1,764)
Observations	2,965	2,882	2,688
labor<30	-4.444*** (1.602)	-3.051*** (0.860)	-2.993*** (0.864)
Observations	2,015	1,944	1,886
labor>30	7.164*** (2.718)	10.49** (4.386)	6.490** (3.125)
Observations	1,950	1,904	1,747

Notes : All models include a dummy for country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[; and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

While the right combination of production factors is critical to a firm's efficiency, the Chinese shock could constitute a threat to firms less developed technologically because they are susceptible to becoming less productive. This hypothesis is tested in Table 3.5 which displays the results of the analysis by interacting with China's penetration and capital intensity status (*Cap_Int*) considering the same model specifications as in the previous table. The Capital intensity is measured by the firm's capital-labor ratio. It takes the value of 1 if it is greater than the median (models 1-3) or than the third quartile (models 3-6). These thresholds are calculated by industry. The results show that African firms with high capital intensity experienced a reduction in sales caused by the Chinese import competition but to a lesser extent compared to others.

TABLE 3.5 – Effect of Chinese penetration on African firm by capital intensity

VARIABLES	threshold=Median			threshold=third quartile		
	[1]-IV	[2]-IV	[3]-IV	[4]-IV	[5]-IV	[6]-IV
$\Delta ChinaPenOut$	-3.294*** (1.255)	-1.709*** (0.589)	-1.749*** (0.600)	-3.170** (1.240)	-1.635*** (0.570)	-1.673*** (0.579)
Cap_Int	-3.563 (5.058)	-3.368 (5.063)	-3.166 (5.324)	2.777 (6.194)	4.243 (6.181)	3.291 (6.291)
$\Delta ChinaPenOut * Cap_Int$	1.802** (0.785)	0.916** (0.412)	0.920** (0.420)	1.488** (0.685)	0.763* (0.398)	0.735* (0.395)
Observations	2,688	2,592	2,424	2,688	2,592	2,424

Notes : All models include the interacting term of the country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[, and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

6.2 Effect of the Chinese shock according to the country's endowment in natural resources

The relationship between natural resources and economic development, especially in developing countries, raises many questions and has been the subject of numerous studies in the literature. Countries with large endowments of natural resources tend to be less diversified and highly dependent on the natural resource sector for tax revenue, foreign exchange, growth, and employment [Hailu, 2017]. According to [Martin, 2005], reducing natural resource dependence is important for several reasons, including (i) the deteriorating terms of trade for commodity exports; (ii) the volatility of commodity prices and their subsequent impact on the domestic economy; (iii) the lower rate of technological change in resource extraction activities compared to other sectors; and (iv) the rent-seeking behavior, weak governance, and civil wars associated with resource-intensive economies. According to the literature ([Downs, 2007], [Alden, 2009], [Powanga, 2019]), China's presence in Africa is explained by its crucial need for raw materials, particularly energy resources, to feed its industries and meet the energy needs of its population. If this is the case, we hypothesize that African countries dependent on natural resources are more exposed to Chinese competition. Countries with large endowments of natural resources tend to develop the extractive sector to the detriment of other sectors, particularly manufacturing. This phenomenon is known as Dutch disease ([Corden, 1982], [Corden, 1984], [Javaid, 2009], [Trevino, 2011], [Rodriguez, 1999]). In the context of the China-Africa partnership, this situation may be exacerbated if China mainly imports raw materials from Africa and exports its manufacturing products to Africa.

However, others scholars have questioned the Dutch disease hypothesis ([Sala-i-Martin, 2004], [Lederman, 2007]). Criticism often goes to the empirical methods used but also the nature of the data ([De V Cavalcanti, 2015]; [Alexeev, 2009] and [Lederman, 2003]). Others point to the per-

iods of study ([Wright, 2004]; [Manzano, 2001]) as well as the indicators used ([Brunnschweiler, 2008a]; [Brunnschweiler, 2008b]; [Ding, 2005]; [Stijns, 2005]). The positive effects of resource dependence are justified by the fact that revenues (taxes and rents) from natural resource exploitation can be used to diversify the national economy through complementarities between the resource sector and other sectors ([Hirschman, 1958]. When these revenues are invested in other sectors throughout the economy, the benefits diffuse through the national production network. Wages paid to workers (in the extractive and non-extractive industries) and spent on consumable goods further transform the national economy. In addition, the government can also use revenues from the extractive sector to build infrastructure (electricity, roads, etc.) and invest in human capital necessary for business growth. By doing so, these companies can reinvest the profits into the acquisition of new technologies and boost their productivity and consequently improve their competitiveness on the international market. Additional sources of foreign exchange accumulation can also be used to finance development. In conclusion, dependence on natural resources can lead to economic development and prosperity in the manufacturing sector if it is accompanied by a policy that can reallocate the resources it generates to other sectors so as to make it transitory and not permanent [Hailu, 2017].

Several approaches are used in the literature to determine a country's dependence on natural resources. Their share of GDP or in total exports ([Davis, 1995]; [Lederman, 2003]), the resource rent in GDP [Dobbs, 2013] is one of the most commonly used indicators. The distinction between natural resource-dependent and non-dependent countries is based on a threshold arbitrarily chosen in the literature, from 10% ([Dobbs, 2013] to 20% ([Baunsgaard, 2012] or 25% ([Haglund, 2011]. Such thresholds have several limitations, including the impossibility, of making comparisons between countries and over time. Similarly, these indicators do not take into account the production environment of non-extractive sectors. To address these limitations, [Hailu, 2017] designed the Extractives Dependence Index (EDI), a composite index consisting of three indicators : i) the share of export earnings from extractives in total export earnings ; ii) the share of the revenue from extractives in total fiscal revenue ; and iii) the extractive industry value added in GDP. These indicators were weighted to take into account the productive capacity of the country in order to determine the presence of alternative sources of export and fiscal revenues as well as the industrial capacity for diversification necessary for structural change in the economy. The EDI for country j at time t is defined as follows :

$$EDI_{jt} = \sqrt{[EIX_{jt} * (1 - HTM_{jt})] * [Rev_{jt} * (1 - NIPC_{jt})] * [EVA_{jt} * (1 - MVA_{jt})]} \quad (3.7)$$

where :

EIX_{jt} : the export revenue from oil, gas, and minerals as a share of total export revenue of country j at time t ;

HTM_{jt} : the export revenue from high-skill and technology-intensive manufacturing as a share of global HTM exported in year t ;

Rev_{jt} : the revenue generated by the extractive industry as a share of total fiscal revenue of country j at time t ;

$NIPC_{jt}$: the total tax revenue collected from non-resource income, profits and capital gains as a share of GDP of the country j at time t ;

EVA_{jt} : the extractives industries value added as a share of GDP of the country j at time t ;
and

MVA_{jt} : the per capita manufacturing value added used as a proxy for domestic industrial capability of country j at time t .

TABLE 3.6 – China's penetration and countries endowment in natural resources

VARIABLES	[1]-IV	[2]-IV	[3]-IV
$\Delta ChinaPenOut$	-6.038*** (1.383)	-3.447*** (0.504)	-3.133*** (0.483)
$\Delta ChinaPenOut * EDI$	0.378*** (0.0579)	0.295*** (0.0341)	0.266*** (0.0336)
EDI	2.891*** (0.589)	6.622*** (0.641)	6.417*** (0.637)
$\Delta FTAPen$		3.317*** (0.804)	3.139*** (0.783)
$\Delta IndPen$		-4.086*** (0.940)	-3.733*** (0.895)
$\Delta chnX_AI_cm * Exp$			-5.578** (2.585)
$\Delta chnX_EUSA_cm * Exp$			-34.97*** (12.28)
Exporter			47.45*** (11.67)
Constant	-93.51** (47.14)	-299.4*** (42.79)	-308.4*** (42.18)
Observations	2,290	2,190	2,150
R-squared		0.293	0.304
IV F-stat	151.8	482	470.5
Wooldridge(p_endog)	0	2.93e-08	5.49e-07

Notes : All models include a dummy for country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[, and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

Table 3.6 shows the effect of Chinese penetration when the country's dependence on natural resources is taken into account ($\Delta ChinaPenOut * EDI$). As in the previous model specification, the penetration of Chinese products continues to have a statistically significant negative impact on African firms' sales. The extractive dependence index (EDI) is positive and significant invalidating the Dutch disease hypothesis. The interactive term between China's penetration and EDI is positive and statistically significant. African firms' sales tend to increase the more a country

is dependent on the extractive sector and the more the Chinese penetration increases. These findings are consistent with the more recent theories about China-Africa economic relationship, according to which, signed agreements between China and natural-resource-rich African countries, lead the former to invest in many infrastructure projects particularly road, rail, and electricity sectors²⁰ ([Powanga, 2019], [Kaplinsky, 2007]).

Working conditions in African firms have improved because they can serve more local and foreign markets. Hence, their TFP improves and they can become more competitive. Countries well endowed in and dependent on natural resources can get foreign currencies, which can reduce financial constraints and facilitate the import of production tools by local firms.

6.3 Regional and sectoral Impacts of China shock

China's penetration in the African market has not evolved uniformly across the continent, both at the country level and at the sector level. For instance, the textile industry has experienced a strong increase in the penetration of Chinese products. Conversely, the agri-food industry has been less exposed to Chinese import competition. As for the other sectors, no common trend emerges. We make the assumption that countries that belong to the same economic region (i.e. ECOWAS, AMU, EAC, CEMAC, SADC) would experience similar Chinese penetration. We estimate some model specifications for these regions. The results shown in table 3.7 therefore relate to these regional communities with the exception of CEMAC, whose number of valid observations is too low to give an estimate. The results are in the line with the benchmark estimations. However, Chinese penetration seems to have a pro-competitive effect in Egypt and Morocco, part of the Arab Maghreb Union (AMU). But when we take into account the competition in the common external markets, this pro-competitive effect disappears. The ECOWAS zone²¹ shows a negative and significant effect but of low magnitude. This shows that China has caused minor damage, on average, to the countries of West Africa. As for the other two zones (EAC, SADC), although the effects are negative, they are not significant and this could reflect a mitigated impact of the Chinese shock in these zones but with a slightly more widespread negative effect. However, we can also assume that the non-significance may be due to the small size of the sub-samples considered.

20. This infrastructure is necessary for mining and transport of natural resources

21. the majority of members of which took part in our estimates

TABLE 3.7 – China shock effect on African firms by economic region

variables	ECOWAS			EAC			AMU (Egypt-Maroc)			SADC		
	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]
$\Delta ChinaPenOut$	-0.442** (0.192)	-0.462** (0.217)	-0.572** (0.235)	-3.284 (3.878)	-2.823 (3.378)	-4.886 (5.096)	11.31*** (2.634)	7.936*** (2.950)	1.105 (2.417)	-23.88 (17.26)	-25.52 (48.63)	-20.06 (34.58)
$\Delta FTAPen$		0.0299 (0.497)	-0.190 (0.505)		1.199 (1.319)	1.773 (1.590)		43.59** (18.56)	18.40 (16.84)		1.249 (3.696)	1.253 (3.120)
$\Delta IndPen$		-1.422** (0.646)	-1.804*** (0.669)		0.401 (0.903)	0.510 (1.210)		-14.81** (7.020)	-30.76*** (8.286)		-0.865 (17.06)	-5.969 (8.298)
$\Delta chnX_AI_cm * Exp$			-8.857*** (3.206)			5.617 (5.560)			6.070 (5.198)			8.248 (17.47)
$\Delta chnX_EUSA_cm * Exp$			7.919 (15.08)			-0.823 (17.45)			-91.67*** (12.31)			21.97 (29.13)
Exporter			66.18*** (15.23)			-26.64 (31.43)			45.99*** (15.10)			-65.15 (64.03)
Constant	-77.09*** (16.99)	-70.58*** (21.10)	-69.47*** (22.17)	-22.28 (35.01)	-25.51 (35.28)	-35.61 (38.12)	71.99*** (25.18)	82.74*** (27.43)	33.40 (21.76)	-49.51 (72.58)	-35.58 (91.81)	-17.65 (67.78)
Observations	721	704	699	430	430	417	2,153	2,153	1,960	581	581	575
R-squared	0.134	0.158	0.176		0.008				0.046			
IV F-stat	173.9	158.5	149.5	23.08	28.93	16.54	133.7	82.55	97.47	6.950	0.870	1.563
Wooldridge(p_endog)	0.0168	0.0682	0.0291	0.292	0.330	0.259	0	1.12e-08	0.00179	0.0840	0.497	0.494

Notes : All models include a dummy for industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[; and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

As far as sector analysis is concerned, the results are quite surprising. Table 3.8 does not reveal any statistically significant effect of Chinese penetration at the industry level. Two explanations are possible. As in the previous case, either it is due to the small size of the sub-samples or it is due to the non-uniformity of the effect of the Chinese shock over the continent. In other words, there is a strong heterogeneity of the impact of the Chinese shock in a given industry by moving from one country to another so that no trend is dominant.

TABLE 3.8 – China shock effect on African firms by industry

Variable	Food and beverages	Textiles and wearing apparel	Wood and paper	Petroleum, chemical, and non-metallic mineral product	Metal products	Electrical and machinery
$\Delta ChinaPenOut$	-141.2 (177.5)	-43.83 (76.34)	-31.19 (21.33)	-9.467 (8.203)	-4.387 (6.583)	1.710 (5.045)
$\Delta FTAPen$	-24.12 (26.44)	-18.22 (27.67)	-7.376 (6.053)	0.316 (0.990)	0.463 (0.908)	-1.141 (2.590)
$\Delta IndPen$	-81.49 (100.3)	-25.88 (44.66)	13.63 (24.11)	-4.237** (2.135)	-0.953 (4.851)	-6.592 (9.171)
$\Delta chnX_AI_cm * Exp$	-43.57 (70.00)	-57.68 (104.9)	-11.61 (47.50)	-9.864 (6.964)	-34.66*** (10.51)	24.25 (23.96)
$\Delta chnX_EUSA_cm * Exp$	-2,437 (2,320)	-113.9 (144.1)	-348.7 (233.7)	-166.7*** (37.74)	-134.2 (90.49)	-82.40** (39.81)
Exporter	335.3 (339.3)	249.4 (289.1)	75.61 (68.62)	114.0*** (25.64)	184.0*** (55.10)	98.76** (50.21)
Constant	523.4 (657.2)	4,862 (8,580)	130.6 (143.0)	-48.36 (38.63)	-75.97 (90.03)	-99.72 (121.2)
Observations	772	991	342	803	506	211
R-squared				0.117	0.046	0.074
IV F-stat	1.569	0.492	8.630	59.85	3.873	5.710
Wooldridge(p_endog)	5.17e-05	0	0.00633	0.787	0.435	0.590

Notes : All models include a dummy for industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[; and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

7 Conclusion

On the international scene, the Chinese shock leaves no country unaffected. This paper analyzed the impact of China's product penetration on African firms' growth. Overall, Chinese competition in Africa is leaving untoward damage in the manufacturing sector. The penetration of Chinese products leads to a significant drop in the growth of African companies. However, it should be noted that this effect is not homogeneous. On the one hand, some firms, such as small, young, and the least capital-intensive are more impacted by Chinese penetration. On the other hand, we find that African firms in resource-dependent countries are less adversely affected by the penetration of Chinese goods. In addition, when the common external market is a developed country, the Chinese shock has a more severe impact on African exports. Moreover, the results reveal that the use of these inputs by African companies leads to a drop in their sales. These results are very important and answer the question "is the Chinese shock an opportunity for African industrialization?" with a "no". Even if a pro-competitive effect is observed for large companies, small and medium-sized enterprises which constitute the main provider of jobs and contribute to the manufacturing sector, are impacted negatively.

The African Continental Free Trade Area (AfCFTA) is one of the flagship projects intended to catalyze the economic and industrial development of the continent. For this to be effective, the continent should change its posture vis-à-vis Chinese trade. As long as Chinese products are cheaper, they will likely compete and gain market share over locally produced goods. This is why Africa must equip itself with all the necessary means to sufficiently boost its manufacturing industry in the face of the Chinese threat and possibly other shocks that could disrupt the proper functioning of the AfCFTA. Concretely, Africa should work to raise the level of total factor productivity of its companies and should invest in education to improve its human capital quality in order to make its investments in research and development more profitable. Furthermore, the availability of electric power is essential for the competitiveness of the manufacturing sector. In that context, the financial sector must be well-developed and well-inclusive to encourage private and public investments.

8 Appendixes

Appendix 1 : Number of reported manufacturing firms by country and year

country	year	number of firms	wto membership	REA
Angola	2005 ; 2009	81	23 November 1996	SADC/ECCAS
Benin	2003 ; 2008 ; 2015	65 ; 73 ; 41	22 February 1996	ECOWAS (UEMOA)
Botswana	2005 ; 2009	52	31 May 1995	SADC
Burkina Faso	2005 ; 2008	33	3 June 1995	ECOWAS (UEMOA)
Cameroon	2005 ; 2008 ; 2015	43 ; 74 ; 47	13 December 1995	ECCAS(CEMAC)
Cape-Verde	2005 ; 2008	30	23 July 2008	ECOWAS
Chad	2008 ; 2017	36	19 October 1996	ECCAS (CEMAC)
Egypt	2003 ; 2006 ; 2007 ; 2012 ; 2015	606 ; 792 ; 932 ; 724 ; 469	30 June 1995	COMESA
Ethiopia	2010 ; 2014	130		COMESA
Ghana	2006 ; 2012	19	1 January 1995	ECOWAS
Ivory-Coast	2008 ; 2015	63	1 January 1995	ECOWAS (UEMOA)
Kenya	2006 ; 2012 ; 2017	106 ; 236 ; 170	1 January 1995	COMESA
Lesotho	2008 ; 2015	31	31 May 1995	SADC
Liberia	2008 ; 2016	47	14 July 2016	ECOWAS
Malawi	2004 ; 2008 ; 2013	47 ; 64 ; 17	31 May 1995	SADC
Mali	2002 ; 2006 ; 2009 ; 2015	68 ; 146 ; 120 ; 60	31 May 1995	ECOWAS (UEMOA)
Morocco	2003 ; 2006	278	1 January 1995	AMU
Niger	2004 ; 2008 ; 2016	42 ; 51 ; 30	13 December 1996	ECOWAS (UEMOA)
Nigeria	2006 ; 2008 ; 2013	156 ; 142 ; 298	1 January 1995	ECOWAS
Rwanda	2005 ; 2010	31	22 May 1996	COMESA
Senegal	2002 ; 2006	70	1 January 1995	ECOWAS (UEMOA)
Sierra-Leone	2008 ; 2016	35	23 July 1995	ECOWAS
South Africa	2002 ; 2006	184	1 January 1995	SADC
Tanzania	2005 ; 2012	83	1 January 1995	SADC
Togo	2008 ; 2015	26	31 May 1995	ECOWAS (UEMOA)
Uganda	2005 ; 2012	126	1 January 1995	COMESA
Zambia	2001 ; 2006 ; 2012	69 ; 160 ; 91	1 January 1995	COMESA
Zimbabwe	2010 ; 2015	190	5 March 1995	COMESA

Notes : CEMAC : Central African Economic and Monetary Community ; UEMOA : West African Economic and Monetary Union ; REA : Regional Economic Area

Source : Author's construction

Appendix 2 : Importer's firm characteristics

year	total country	total firm	Exporter	small firm (size ≤ 100)	medium-sized firm (100 < size ≤ 500)	large firm (size > 500)	Export Share in output	private domestic owned share	foreign owned share	state owned share	imported input share
2001	1	45	17,778	80,000	20,000	0,000	15.000 (4.629)	78.189 (39.755)	20.700 (38.188)	1.111 (7.454)	55.933 (31.601)
2002	3	184	42,391	59,783	29,891	10,326	30.614 (23.651)	76.953 (40.559)	19.709 (37.519)	2.646 (14.644)	50.832 (30.706)
2003	3	432	24,769	55,556	34,954	9,491	45.391 (30.454)	83.891 (33.615)	12.490 (30.526)	2.618 (14.928)	62.306 (29.462)
2004	2	80	13,750	82,500	15,000	2,500	50.091 (27.840)	76.776 (39.926)	21.687 (38.676)	1.250 (11.180)	76.013 (29.825)
2005	8	282	20,213	78,723	17,376	3,901	29.739 (25.254)	73.787 (40.561)	24.794 (39.804)	0.710 (4.841)	63.091 (29.832)
2006	9	689	30,914	58,491	35,994	5,515	37.449 (26.603)	82.915 (35.178)	16.218 (34.287)	0.408 (4.445)	56.871 (30.130)
2007	1	384	38,281	46,354	31,250	22,396	33.847 (22.894)	88.688 (29.093)	3.962 (17.314)	4.057 (18.854)	47.747 (25.471)
2008	13	315	23,175	78,095	18,095	3,810	31.877 (20.958)	75.600 (39.087)	18.851 (35.432)	0.632 (5.450)	66.263 (30.150)
2009	3	126	18,254	87,302	11,111	1,587	37.896 (24.273)	68.320 (42.714)	21.615 (38.385)	1.295 (8.197)	53.190 (29.464)
2010	3	187	16,043	62,032	31,016	6,952	33.667 (22.473)	87.308 (28.838)	10.953 (27.273)	1.738 (8.873)	52.326 (30.300)
2012	6	642	35,047	63,396	24,455	12,150	37.587 (23.866)	86.701 (30.351)	11.292 (28.348)	0.980 (7.749)	50.917 (26.391)
2013	2	116	38,793	87,069	12,931	0,000	40.000 (19.569)	67.731 (39.885)	6.898 (17.168)	4.259 (11.394)	43.595 (21.531)
2014	1	77	20,779	48,052	36,364	15,584	49.938 (28.408)	73.221 (42.217)	24.013 (39.956)	2.766 (14.564)	52.688 (27.604)
2015	8	493	29,817	64,097	26,572	9,331	35.231 (22.831)	80.200 (35.071)	11.271 (27.344)	1.700 (9.669)	55.874 (27.342)
2016	3	46	19,565	91,304	8,696	0,000	31.778 (18.226)	69.444 (44.597)	25.000 (41.806)	0.444 (2.981)	63.348 (30.952)
2017	2	122	30,328	75,410	21,311	3,279	25.324 (12.042)	84.664 (32.002)	14.598 (32.053)	0.000 (0.000)	54.492 (30.028)

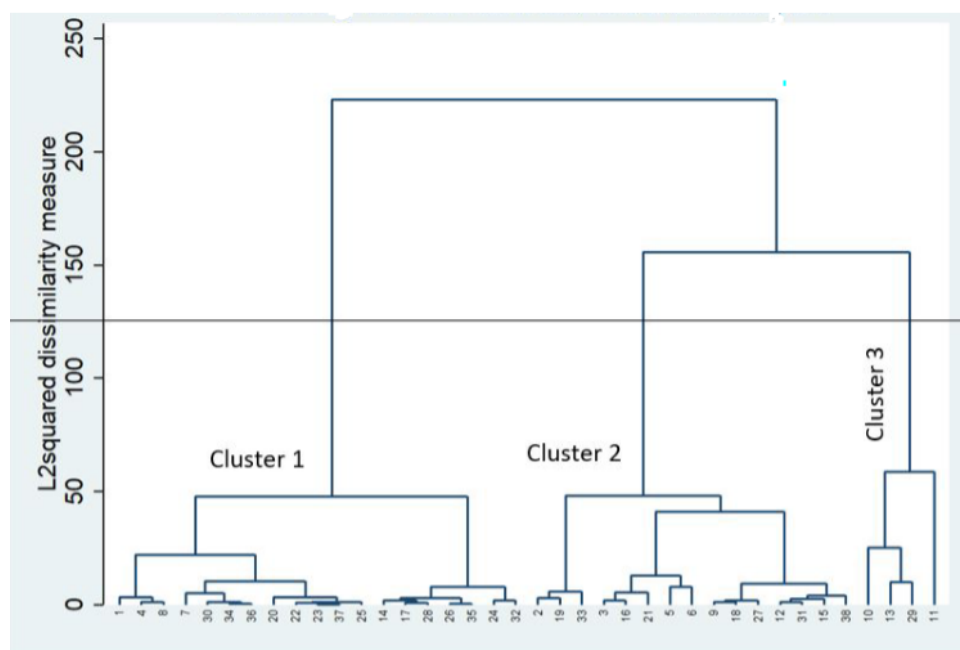
Source : Author's calculation

Appendix 3 : Non Importer's firm characteristics

year	total country	total firm	Exporter	small firm (size ≤ 100)	medium-sized firm (100 < size ≤ 500)	large firm (size > 500)	Export Share in output	private domestic owned share	foreign owned share	state owned share	imported input share
2001	1	24	25	70,833	25	4,167	30,667 (23,847)	77,348 (39,726)	22,652 (39,726)	0,000 (0,000)	2,600 (2,191)
2002	3	138	4,348	78,261	18,116	3,623	23,840 (18,020)	89,860 (27,546)	7,713 (23,948)	2,412 (14,837)	1,966 (2,383)
2003	3	517	1,161	89,555	9,091	1,354	38,406 (27,150)	96,657 (16,365)	2,108 (12,722)	0,688 (7,969)	1,814 (2,413)
2004	2	9	66,667	77,778	22,222	0	10,000 (0,000)	100,000 (0,000)	0,000 (0,000)	0,000 (0,000)	0,000 (0,000)
2005	8	197	3,046	93,908	5,076	1,015	44,144 (33,710)	90,174 (28,671)	8,718 (27,304)	0,595 (6,067)	1,575 (2,234)
2006	9	1222	0,491	72,013	19,067	8,919	36,439 (25,946)	89,648 (28,662)	5,500 (21,179)	3,520 (17,905)	2,939 (2,161)
2007	1	548	1,095	78,102	16,788	5,109	36,507 (24,728)	94,248 (22,421)	1,022 (9,846)	1,774 (12,567)	1,627 (2,490)
2008	13	390	1,538	92,051	6,923	1,025	48,771 (28,644)	86,856 (31,489)	11,186 (29,553)	0,653 (6,148)	1,699 (1,330)
2009	3	127	4,724	96,062	3,937	0	33,333 (25,820)	84,148 (35,193)	5,696 (22,438)	0,635 (4,435)	2,279 (1,297)
2010	3	163	3,681	78,527	17,178	4,294	48,000 (23,720)	95,507 (17,073)	3,555 (14,855)	0,253 (3,062)	2,063 (2,265)
2012	6	637	0,942	86,813	10,047	3,139	38,489 (23,975)	91,550 (25,503)	5,915 (22,048)	0,714 (5,638)	2,195 (2,207)
2013	2	199	3,015	96,482	3,517	0	42,619 (23,432)	81,166 (36,250)	2,209 (10,063)	0,982 (5,796)	1,583 (1,442)
2014	1	53	11,321	64,151	33,962	1,887	47,333 (12,702)	88,580 (29,961)	11,420 (29,961)	0,000 (0,000)	4,600 (0,894)
2015	8	434	1,382	90,092	8,295	1,613	40,432 (25,055)	88,301 (29,578)	6,427 (22,459)	0,963 (7,356)	1,622 (2,103)
2016	3	66	9,091	93,939	6,061	0	10,000 (...)	80,476 (39,531)	6,349 (24,580)	0,000 (0,000)	1,091 (1,044)
2017	2	84	7,143	90,476	5,952	3,571	55,800 (34,851)	93,096 (23,642)	3,976 (18,995)	1,000 (9,110)	2,375 (2,264)

Source : Author's calculation

Appendix 4 : Dendrogram of non-African countries classification based on factorial axis



Source : Own elaboration

Notes : The horizontal axis reports the matched countries. Non-African countries are numbered from 1 to 10. The horizontal line shows the cut-off level and the three classes obtained. The vertical axis reports the dissimilarity measure constructed with the L2 norm that is calculated as the square root of the sum of the squared vector values.

Appendix 5 : Results from instrumentation of Indian penetration

Variables	[1]	[2]	[3]
$\Delta ChinaPenOut$	-4.671*** (1.557)	-5.324*** (1.887)	-5.168*** (1.808)
$\Delta IndPen$	-4.813 (3.185)	-1.978 (3.292)	-0.185 (3.042)
$\Delta FTAPen$		-1.648*** (0.576)	-1.587*** (0.561)
$\Delta chnX_AI_cm * Exp$			-7.910*** (2.936)
$\Delta chnX_EUSA_cm * Exp$			-26.29*** (8.624)
Exporter			39.28*** (8.727)
Constant	30.32 (29.86)	57.29 (38.78)	45.76 (38.57)
Observations	3,956	3,868	3,651
IV F-stat	13.28	11.32	15.01
Wooldridge(p_endog)	6.71e-11	6.54e-11	2.97e-09

Notes : All models include a dummy for country (μ_j), industry (λ_k), time (ρ_t) and electricity (<20;[20,40[;[40,60[;[60,80[, and [80,100]); Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; IV refers to 2SLS estimator with $\Delta ChinaPenOut$ instrumented with the correspondent instrument constructed

Chapitre 4

African firms' adaptation to Chinese Shock under financial and electricity constraints

Les liens commerciaux entre la Chine et les pays africains se sont intensifiés au cours des deux dernières décennies, faisant de la Chine le premier partenaire commercial de l'Afrique. Dans cet article, nous nous concentrons d'une part, sur les effets de la concurrence des importations chinoises en Afrique sur la productivité des entreprises locales et sur leur intensité énergétique. D'autre part, nous investiguons l'éventuelle relation mutuelle existante entre la productivité et la consommation d'énergie (c'est-à-dire l'intensité énergétique des entreprises). En utilisant une approche de variable instrumentale, nous montrons que la productivité et l'intensité énergétique des petites et moyennes entreprises sont affectées négativement par la concurrence des produits chinois, alors que nous ne trouvons pas d'impact statistiquement significatif sur la performance des grosses entreprises. Cependant, l'amélioration de la productivité de l'entreprise entraîne une baisse de son intensité énergétique, mais il n'y a pas de preuve de causalité inverse. Par conséquent, plus les entreprises perdent en efficacité technique (TFP) suite à la pénétration chinoise, plus elles perdent en efficacité énergétique. Nous montrons également qu'en fonction de la nature des obstacles à leur croissance, les petites et les grandes entreprises s'adaptent différemment à la concurrence chinoise. Parmi les petites et moyennes entreprises, seules celles qui sont confrontées à une pénurie d'électricité améliorent leur performance énergétique, tandis que parmi les grosses entreprises, une meilleure performance n'est observée que parmi celles qui sont confrontées à des obstacles financiers.

1 Introduction

China-Africa cooperation has been growing over the years and attracted a lot of attention. This cooperation has been strengthened since China joined the WTO, and stands out in different ways. Chinese foreign direct investment (FDI) inflows in Africa and bilateral trade between the two regions have expanded significantly. These changes are not without impacts on African economies. In this paper, we focus on the impact of Chinese imports on African firms' performance. The literature suggests that China's penetration in foreign markets, generally, led to a decrease in firms' growth but this impact is heterogeneous across firms according to their characteristics

([Bugamelli, 2010], [Mercado, 2019], [Malgouyres, 2017]). For instance, while small and young enterprises are vulnerable, large ones can benefit from pro-competitive effects ([Li, 2019], [Blyde, 2020]). The Chinese competition may constrain local firms to reinforce their performance, in particular their productivity. A firm is more productive than another one if it is able to produce the same outputs with fewer inputs or if it produces more outputs using the same inputs [Van Biesebroeck, 2003]. To exist in the market, a firm must reach a minimum level of productivity that requires, in turn, a minimum level of capital stock according to its production function [Olley, 1992]. A firm's market power increases with its productivity [Melitz, 2003]. For a firm, an increase in the stock of capital means an improvement in productivity and hence the market power that increases the probability of staying in the market. Without high productivity, African firms' response to China's penetration is likely to be challenging. Their productivity can decrease as a result of a decrease in production or may increase as a result of a special investment.

According to the literature, one of the major obstacles faced by African firms is the low access to financial markets [African Economic Outlook, 2019]. In such a context, investment in new equipment can be a challenge mainly for young and small enterprises ([Beck, 2006a], [Okpara, 2007], [Fowowe, 2017]). This situation could explain the heterogeneous impact of China's pene-

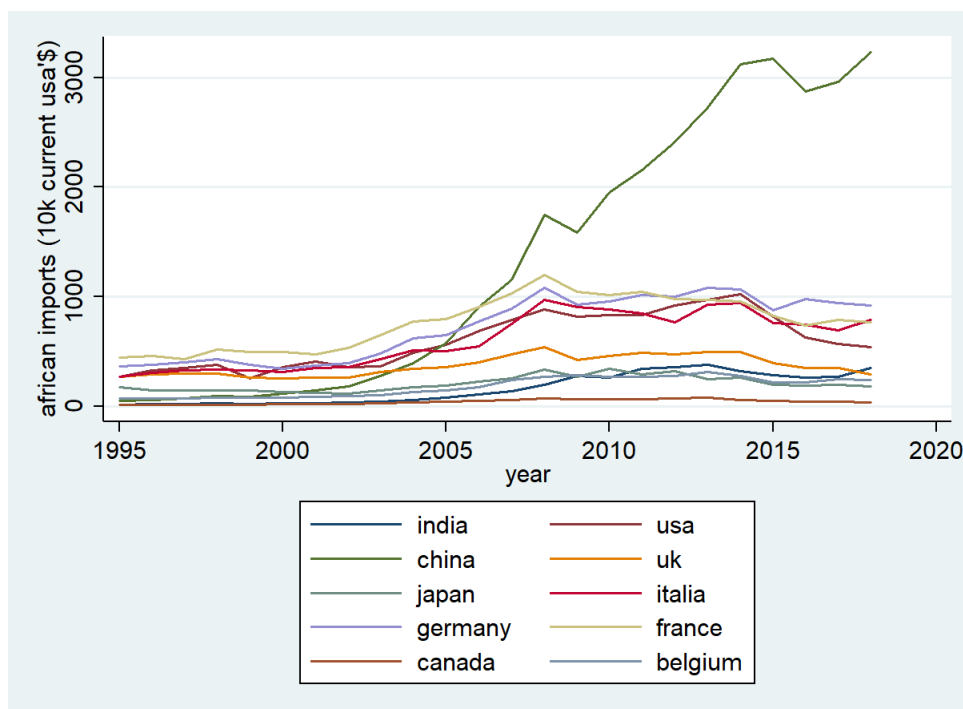


FIGURE 4.1 – African imports of electrical appliances from major exporters (source : Own elaboration [Data from BACI, CEPII])

-tration into African markets across firms. However, as shown in Figure 4.1, for more than two decades, China has become, thanks in large part to more competitive prices, the main supplier of machines, motors, and other electrical and electronic products to African countries. Access to affordable imported inputs and equipment can facilitate firms' investment at a lower cost. As

a result, Chinese inputs may also generate productivity gains for African firms. Furthermore, The literature points to low electricity quality as another obstacle faced by manufacturing firms in Africa ([African Economic Outlook, 2019], [Alby, 2013], [Gelb, 2011]). Low electricity quality increases the cost of energy use, making the production more energy-intensive and firms less competitive. This can lead firms to invest in energy efficiency to overcome the access to low-quality electricity. Like in the productivity case and according to Figure 4.1, Chinese products still constitute a good opportunity for African firms to have access not only to energy-efficient appliances but also to energy-saving technologies. The direct advantage of importing these products is low energy consumption which means more profit for the enterprise. Another advantage is the reduction in CO_2 emissions. Fossil fuels still continue to be an important source of electricity generation in African countries ([Lin, 2021], [Lin, 2022]) and making the continent a major emitter of CO_2 relative to its GDP. But, as shown in Figure 4.2, even if total CO_2 emissions increased significantly since the early 2000s, its rate relative to GDP decreased significantly over the same period. The increase in these total emissions can be explained by accelerated economic growth in the African continent and the adoption of new technologies.

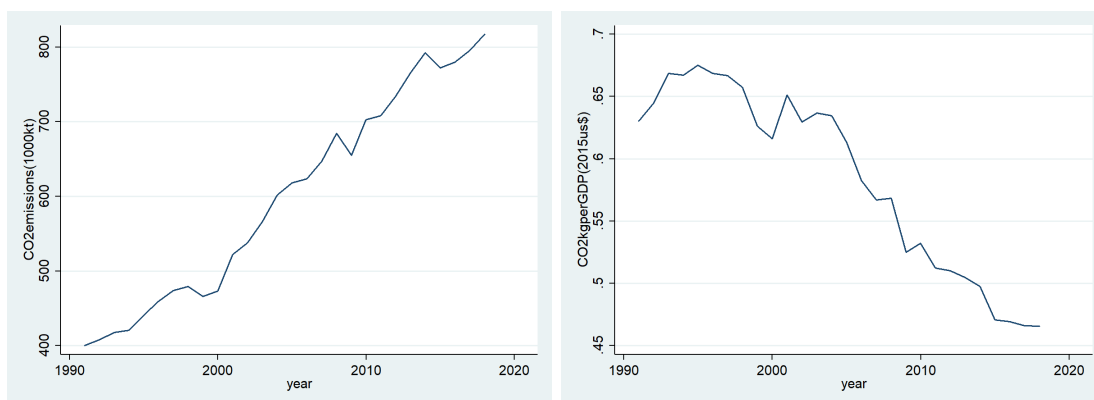


FIGURE 4.2 – Total CO_2 emissions and CO_2 per GDP in Sub-Saharan Africa (source : Own elaboration [Data from WDI World Bank])

The objective of this paper is to investigate, at the firm level, the relationship between Chinese penetration, firms' productivity, and energy intensity in African countries. First, we propose a conceptual framework that explains theoretically the link between our main variables that is energy intensity (or energy efficiency), productivity, and production. Second, we apply the two-stage least square (2SLS) approach to assess the impact of Chinese penetration into African markets on firms' productivity and energy intensity. In addition to the 2SLS method, we used the three-stage least square (3SLS) estimators to estimate a simultaneous equation model that links productivity and energy intensity.

Results show that China's competition in African markets leads to a reduction in the productivity and energy intensity of small enterprises, but does not affect the large ones. According to our theoretical model, the reduction in energy intensity is associated with a reduction in production rather than productivity improvement. We also find that following China's penetration, productivity improves in SMEs facing electricity obstacles and large firms facing financial

obstacles. Finally, the results suggest that improving a firm's productivity tends to decrease the energy intensity but we do not find any significant reverse causality.

This paper builds on two strands of the literature on trade openness, namely the one focusing on a firm's productivity and the one addressing firms' energy efficiency. Likewise, this paper is closed in spirit to the literature linking firm productivity with its energy intensity, and the one concerning trade and environmental pollution.

The rest of the paper is organized as follows. The first two sections present the literature review on trade and firms' performance (section 1) and the theoretical relationship between energy intensity, productivity, and production at the firm level (section 2). The next section presents the empirical strategy while section 4 presents data and main variables. The empirical results are presented in section 5 while section 6 presents the robustness check analysis. Finally, we concluded and made some policy recommendations.

2 Literature Review

2.1 Trade Openness and Productivity in the Manufacturing Sector

Joining the WTO is considered as a trade opening. Most African countries joined it when it was created in 1995, while China only joined at the end of 2001. WTO membership has resulted in an increase in trade between Africa and the rest of the world (notably, China), a decrease in import costs (customs tariffs), and a diversity of imported goods in terms of quality and variety. China, in particular, is able to produce a wide range of goods at markedly lower prices than most of its competitors. Lower prices and diversity in imported products are both an opportunity for consumers and producers. For firms, we distinguish two types of products, namely (variable and fixed) inputs, and outputs. Inputs are transformed upstream to produce outputs. Trade openness allows firms to have access to low-cost, high-quality inputs, which not only reduce their production costs but can also improve their productivity ([Melitz, 2003]; [Bernard, 2003]). As a result, firms have room to adjust their output prices ([Thompson, 1997]; [Horiuchi, 2009]; [Ades, 1999]; [Frankel, 1999]; [Alesina, 2000]). On the output side, lower tariffs create competition in the domestic market and may crowd out local products. As a result, increased import competition may lead to a reduction in the growth and productivity of less competitive local firms. Local firms can adjust to the new market conditions reducing their production costs and increasing their productivity through the adoption of new technologies. Trade openness promotes the influx of goods designed with different technologies into their market. Local firms can absorb the technology incorporated in imported products and adjust it to the local conditions ([Falvey, 2000], [Hafner, 2011]). Consequently, the adoption of these new technologies can enhance their performance.

Trade openness also leads to a reallocation of the factors of production with some less competitive sectors contracting and other competitive sectors expanding. ([Melitz, 2003], [Hoekman, 2010], [Melitz, 2014]). Moreover, due to the absence of protection of intellectual property rights, developing countries tend to invest little in research and development (RD), which is an important instrument used by many developed countries to face Chinese competition in their domestic

market ([Dorn, 2020], [Bloom, 2016]; [Chen, 2005]). RD allows for product and technological innovation. Innovation in product design gives companies market power over these products because they are not manufactured elsewhere. Technical innovation, on the other hand, has a direct impact on productivity by saving time and inputs ([Grazzi, 2016], [Crowley, 2018], [Hall, 2011]). These different phenomena have been highlighted in the literature. [Amiti, 2007] studied the impact of Indonesia’s trade openness on firm productivity and found that lower tariffs led to an increase in productivity. The effect of intermediate goods is higher (than for finished goods), especially for firms using intensively these goods. The same result was found by [Kasahara, 2008] when analyzing the evolution of the productivity of Chilean firms that move from non-importing to importing intermediate goods and by [Schor, 2004], in the case of Brazilian firms. This effect of intermediate goods has, however, been found to vary under certain conditions. In addition to [Amiti, 2007], [Luong, 2011] found for Mexican firms that when intermediate goods are highly substitutable rather than complementary, lower tariffs on intermediate goods have a positive effect on productivity. Conversely, lower tariffs on finished goods have a negative effect on a firm’s productivity. Similarly, [Altomonte, 2014] showed that the penetration of foreign intermediate goods improves most the productivity of firms located upstream of the industrial production chain.

[Elu, 2010] found that Chinese FDI and trade openness (input and output penetration) with China had no impact on firms’ productivity in Ghana, Kenya, Nigeria, South Africa, and Tanzania. [Darko, 2021] found a positive impact of Chinese goods penetration in Sub-Saharan Africa (SSA) on the productivity of manufacturing firms. This impact is positive for both inputs and outputs. The discrepancy in the outcomes of these different studies may be attributed to different datasets used¹. In particular, the first paper covers only a few years of Chinese trade shock that really materializes after its adhesion to WTO.

2.2 Trade Openness and Energy Intensity in the Manufacturing Sector

Energy intensity (EI) is the amount of energy consumed per unit of output produced. It is calculated by dividing the total energy consumed by the total associated output. Higher energy intensity means that a firm’s production process uses a lot of energy, maybe even wasting energy, which could translate into financial loss and ultimately affect the firm’s competitiveness. Faced with competition, every company seeks to optimize production costs, which include tangible inputs (e.g., raw materials or semi-finished products) and non-tangible inputs (e.g., electricity, internet). As tangible inputs are less compressible than other inputs. In the case of non-tangible inputs such as electricity, the best-known and most widely adopted optimization method by companies is improving energy efficiency (IEE), which is measured as the ratio of useful energy to the energy consumed by a system. IEE is, therefore, about rationalizing the use of energy (and not about saving energy) i.e., reducing energy consumption without altering the level of production. In other words, it represents the economic gains from spending less energy than

1. Indeed, the periods and number of countries in these different analyses are not the same. [Elu, 2010] used a sample of five SSA countries over the period from 1992 to 2004, while [Darko, 2021]’s data covered 24 SSA countries over the period from 2003 to 2018

before for the same level of production.

Trade openness can influence energy intensity in several ways. It allows firms to have access to energy-saving technologies and good quality inputs that improve their productivity and, therefore, their energy intensity ([Keller, 2004], [Imbruno, 2018], [Cui, 2020], [Gutiérrez, 2018], [Holladay, 2016]). This phenomenon is more common among exporting firms, which take advantage of cheaper inputs to improve their productivity and energy intensity and make their exports more competitive ([Kimura, 2006], [De Loecker, 2007], [Bas, 2012]). However, competition from foreign goods in the domestic market can also increase a firm's energy intensity through the reduction of its domestic market share. Indeed, by reducing its domestic market share, the firm reduces its production level which can reduce its productivity and consequently increase its energy intensity ([Shen, 2019]). This situation can be exacerbated in countries where companies are faced with the problem of load shedding -i.e. distributing demand for electrical power across multiple power sources- ([Adom, 2015], [Adom, 2018]). It is also important to note that a structural change in the economy, induced by trade policy, can also lead to an increase in energy intensity at the macroeconomic level ([Cole, 2006], [Mulder, 2012] [Chintrakarn, 2013], [Adom, 2016], [Ma, 2017]). For instance, foreign competition may compel a multi-product firm to specialize, or simply to shift toward less energy-intensive goods due to high prices and bad quality of electricity (this is mainly the case in African countries). Thus, to reduce their vulnerability, some firms opt to innovate rather than import foreign technologies ([Dorn, 2020], [Liu, 2020]), to increase their productivity and hence their energy intensity. In countries where electricity is expensive or of poor quality, it is also desirable to invest in energy-saving technologies or operations capable of reducing corporate energy intensity ([Roy, 2015], [Gutiérrez, 2018], [Barrows, 2021]).

Strategies adopted by companies to adjust to trade policies often require investment, and thus the need for access to bank credit, especially when the company's own resources are insufficient. Unfortunately, in developing countries and especially in Africa, the financial market is less developed, and access to bank credit is an obstacle to investment projects and a brake on the growth of companies ([Green, 2013], [Fauceglia, 2015]). Several papers have analyzed the impact of financial development on corporate energy intensity. Many of them report a negative relationship between access to finance and the energy intensity of firms ([Adom, 2020], [Xue, 2021]). For example, [Amuakwa-Mensah, 2018] showed that improved banking performance encourages investment in energy efficiency in Sub-Saharan Africa, both in the short and long term. However, other studies have found a positive relationship between financial development and energy intensity. For example, in the absence of enforcement measures or rules to limit air pollution, some companies have been found to pay little attention to energy efficiency when they receive bank financing ([Haider, 2019], [Ling, 2020], [Zhang, 2020]). Several factors can explain this firm's behavior. First, there is a lack of sufficient information about which investments are profitable for the company [Velthuisen, 1995]. This insufficient information may be due to high transaction costs ([DeCanio, 1998], [Sanstad, 1994]; [Howarth, 1995]) associated with collecting it, or a lack of qualified staff to conduct the necessary and relevant analyses about the projects ([Beckenstein, 1986]; [De Almeida, 1998]; [Gabel, 1993], [Howarth, 1995], [DeCanio, 1994]). Se-

cond, when facing financial constraints, companies ration capital ([Ross, 1986], [Howarth, 1995]; [Worrell, 1997]) so that energy efficiency becomes just a criterion used in the purchase of capital goods and, therefore, does not require any particular investment or attention [Reddy, 1991]. On the other hand, some studies have shown that despite the existence of a positive net present value of an energy efficiency investment project, some companies remain wary and reluctant to undertake this investment. This is the paradox of energy efficiency ([DeCanio, 1998], [Van Soest, 2001]). Several reasons, including uncertainty about the future, explain this mistrust [Hassett, 1993]. Indeed, investment in energy efficiency would not bring the same benefit to the company if the price of electricity were to fall in the short or medium term. Another reason put forth by [Van Soest, 2001] is that companies are willing to bear the cost associated with postponing investment in energy efficiency in the hope that, thanks to technical progress, more sophisticated technologies may appear in the near future.

2.3 Trade openness, Productivity, and Energy Intensity

The literature investigating the link between total factor productivity (TFP) and energy intensity within firms is mixed. There are two categories of analysis due to the bi-directional causality between these two variables [Berndt, 1978]. First, improving productivity can have a negative impact on energy intensity. Indeed, all investments in new equipment or accessibility to better and cheap intermediate inputs to improve productivity [Darko, 2021], reduce firm energy intensity, all else equal. This is the same for the process of production reorganization and firm innovation in response to increased Chinese competition [Shu, 2019], which can affect energy intensity through productivity improvement. This result reflects the fact that productivity improvement leads to a fall in the energy consumed per unit produced, that is, a decrease in energy intensity. Second, the firm can directly target energy efficiency [Pan, 2019] by investing in energy-saving technology or cleaning up its energy system by reducing energy loss (in all its forms) identified after the energy audit. Likewise, investment in energy-efficient equipment and in research development can also lead to a drop in energy intensity [Hodson, 2018]. The decrease in total energy used can also lead to improving the productivity of the energy factor, and hence, increasing TFP. Therefore, the investment in energy efficiency that decreases the energy intensity, results in an increase in TFP, due to the improvement of energy productivity. Figure 4.3 depicts both channels :

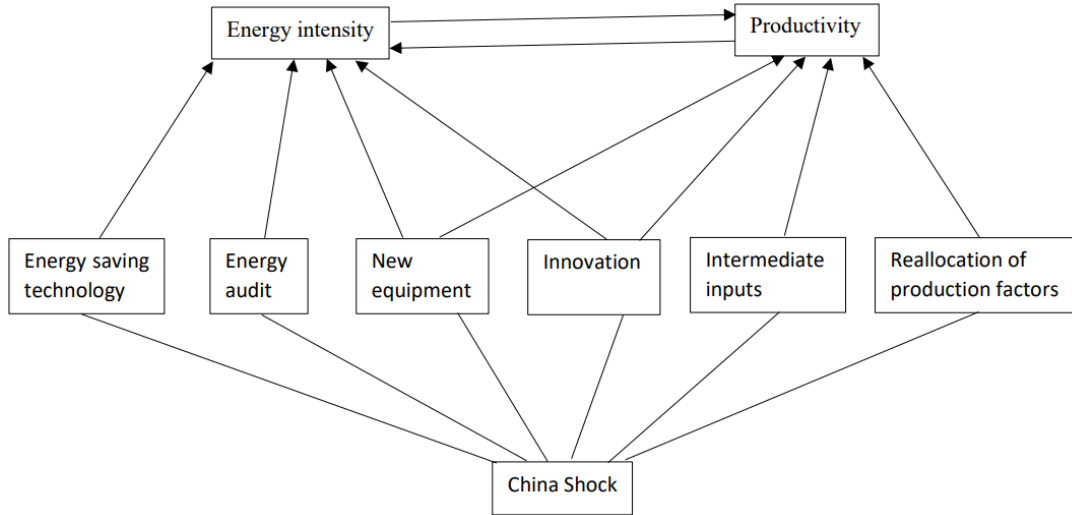


FIGURE 4.3 – Energy intensity and productivity relationship (source : Own elaboration)

The literature review discussed above suggests that Chinese competition can affect firm energy intensity and productivity in several ways. In the next section, we investigate theoretically the relationship between productivity and energy intensity.

3 A simple production framework

As mentioned above, the general decline in firm growth due to Chinese competition in the African market can be mediated through two main channels, namely productivity and energy intensity. In this section, we present a mechanism that relates these two variables to Chinese competition. Assume a firm i with the following neoclassical production function :

$$Q = AK^\alpha L^\beta E^\gamma M^\lambda$$

where A is the productivity of the firm, K is the stock of physical capital, L is labor, E is energy and M is intermediate goods. The parameters α , β , γ , and λ represent the elasticities of production with respect to the corresponding production factors.

Energy intensity is defined as energy consumption per unit produced :

$$EI = \frac{E}{Q}$$

Where EI is the energy intensity, E is the total energy consumed by the company over a given period (e.g. a year) and Q is the company's production over the same period. Let be :

$$EI = \frac{E}{AK^\alpha L^\beta E^\gamma M^\lambda} = \frac{E^{(1-\gamma)}}{AK^\alpha L^\beta M^\lambda}$$

Suppose that energy consumption varies while other factors (K , L , M) remain constant. This means that the production level remains also unchanged. This is possible if, for instance, the firm

invests in energy efficiency² or maintains its production process by reducing the waste of energy in all its forms (thermal, electrical, etc.). This leads to a reduction in the energy consumed but with the same level of output. Likewise, a failure in the process can increase the quantity of energy consumed without affecting other factors or the quantity produced.

To summarize, we suppose that the firm wins or loses in energy efficiency at the same level of production. To take into account this phenomenon, we derive the above expression by the energy variable (E) while maintaining other factors constant. We obtain the following expression :

$$\begin{aligned}\frac{dEI}{dE} &= \frac{(1-\gamma)E^{(-\gamma)}}{AK^\alpha L^\beta M^\lambda} = \frac{1-\gamma}{AK^\alpha L^\beta E^\gamma M^\lambda} \\ \frac{dEI}{dE} &= \frac{1-\gamma}{Q} \\ dEI &= \frac{1-\gamma}{Q} dE\end{aligned}$$

Now, to see how energy intensity varies as a function of production (Q), divide the precedent equation by dQ . Here we allow energy to vary as a function of output (Q) and we suppose that the change of energy intensity as a function of Q does not depend on the initial level of energy intensity³. Then, we obtain the following expression :

$$\frac{dEI}{dQ} = \frac{(1-\gamma)}{Q} \frac{dE}{dQ}$$

In physical science, the energy consumed by a machine is equal to the product of its power (P) and the duration (t) of operation :

$$E = P * t$$

The previous equation thus becomes :

$$\begin{aligned}\frac{dEI}{dQ} &= \frac{(1-\gamma)}{Q} \frac{d(P * t)}{dQ} \Rightarrow \frac{dEI}{dQ} = \frac{(1-\gamma)P}{Q} \frac{dt}{dQ} \\ \frac{dEI}{dQ} &= \frac{(1-\gamma)P}{Q} \frac{1}{\frac{dQ}{dt}}\end{aligned}$$

Let μ be the time productivity of the firm, defined as the firm's output per unit of time

$$\mu = \frac{dQ}{dt}$$

The change in energy intensity can be formulated as follow :

$$\frac{dEI}{dQ} = \frac{(1-\gamma)P}{Q} \frac{1}{\mu}$$

2. without changing significantly its capital stock that serves directly to the production.

3. This assumption is important because we support that energy consumed changes without changing output level.

$$dEI = \frac{(1 - \gamma)P}{\mu} \frac{dQ}{Q}$$

Passing to the integral, we obtain :

$$\int dEI = \frac{(1 - \gamma)P}{\mu} \int \frac{dQ}{Q} \Rightarrow EI = \frac{(1 - \gamma)P}{\mu} \ln(Q) + EI_0$$

The constant term ⁴ EI_0 represents the incompressible energy intensity of the company. It corresponds to the minimum production (Q_{min}) of the company and the associated energy consumption (E_{min}). The minimum production level corresponds to zero profit. Below Q_{min} , the firm is no longer viable in the market and must leave it so as to avoid negative profits. The associated energy E_{min} is equal to the sum of the amount of fixed energy (i.e. that does not depend on production) and the variable energy consumed (by machines, motors, apparatus, etc.) in producing Q_{min} . The time productivity depends on TFP (A). When A increases, μ also increases. Similarly, installed capacity depends on the capital stock, all other things being equal. Let us therefore posit :

$$\mu = \mu^A \quad \text{and} \quad P = P^K$$

Hence the following expression for energy intensity :

$$EI = \frac{(1 - \gamma)P^K}{\mu^A} \ln(Q) + EI_0$$

To analyze this expression from a dynamic point of view, it is necessary to distinguish between the short-term and the long-term. According to economic theory, physical capital varies only in the long run. We admit that productivity (μ^A), as well as installed power (P^K), also vary in the long run since they depend on the stock of physical capital. We, therefore, have the following expressions :

In the short term

$$EI_t = \frac{(1 - \gamma)P^K}{\mu^A} \ln(Q_t) + EI_0 \Rightarrow \Delta EI = \frac{(1 - \gamma)P^K}{\mu^A} \Delta \ln(Q)$$

According to this expression, there is a positive relationship between production and energy intensity. The latter evolves in the same direction but in a non-linear manner with production because of the logarithmic form of Q ⁵. When production increases (decreases), the energy consumed also increases (decreases), but less quickly than the increase (decrease) in production. A firm with a high elasticity of production relative to energy (i.e. γ) tends to have a lower energy intensity. While the power value is linearly related to the change in EI, there is an inverse relationship between this latter and the firm's TFP. With increased trade competition, the EI

4. It is constant over a period (for instance 1 year) but can vary from one period to another.

5. Non-linear relationship between energy intensity and production has been found empirically by [Sahu, 2016].

decreases less quickly in less productive firms (all else being equal) but more quickly in high capital-intensive firms (all else being equal).

In the long term

$$EI_t = \frac{(1-\gamma)P_t^K}{\mu_t^A} \ln(Q_t) + EI_{0t} \Rightarrow \Delta EI_t = \Delta \left(\frac{(1-\gamma)P_t^K}{\mu_t^A} \ln(Q_t) + EI_{0t} \right) \Rightarrow \Delta EI_t = \Delta \left(\frac{(1-\gamma)P_t^K}{\mu_t^A} \ln(Q_t) \right) + \Delta(EI_{0t})$$

Here, the period t is at least 1 year. In the short- and long-term, γ is assumed to be constant because we suppose that the firm's production function remains unchanged. The incompressible energy intensity varies in the long term because, from one period to another, the company can expand or shrink from the administrative point of view, which would reduce the fixed energy component. Similarly, the minimum production level can also vary according to market realities. Moreover, although the relationship between each variable in the expression and EI has not changed, it is nevertheless difficult to analyze the evolution of energy intensity because it depends on the simultaneous variation of all the variables in the equation. However, it should be noted that energy intensity improves, if and only if the firm invests in energy efficiency to reduce installed capacity and/or also invests in advanced technologies to improve its productivity. Energy intensity increases with installed power while it decreases with productivity.

4 Empirical strategy

4.1 Impact of China's penetration on firms' productivity

As noted above, China's penetration into the African market can influence firms' productivity in different ways mainly through import competition of inputs and output. On the one hand, imports of Chinese output generate competition that leads to a loss of a firm's market share and consequently a reduction in productivity. On the other side, Chinese input penetration can facilitate investment in new capital goods or the reduction in intermediary input prices that generate both productivity gain and economy of scale. In this paper, we focus on output penetration due to data limitations. In enterprise survey data, there is no detailed information about the origin of imported inputs used by each firm.

The effect of Chinese imports on African firms' productivity has not been extensively investigated in the literature. [Darko, 2021] is among the few papers that addressed the issue with a comprehensive dataset and empirical strategy. However, the instruments used in their analysis namely maritime transport shock⁶ and China's comparative advantage shock did not fully respect the required homogeneity condition. According to the maritime transport measure, a firm's exposition to China's penetration increases as a seaport with good quality (size and depth) is near. However, the proximity to a seaport cannot affect firms' productivity without favoring, in advance, the entry of Chinese products. This statement can be a bit problematic because a firm that is near a large seaport is not only exposed to Chinese products but also to all foreign products. Moreover, this proximity to the seaport can facilitate its exports, and imports of goods

6. The instrument takes into account the size, depth, the proximity of the seaport to the enterprise.

(such as capital goods or intermediary inputs) that can improve its productivity. Then it's possible that the proximity to a large port affects a firm's productivity without passing by China's penetration. Concerning the second instrument that follows [Autor, 2013], its appropriateness is questionable since the authors used other Sub-Saharan countries to construct it. Indeed, even if the intra-African trade is not yet quite developed, there is a strong link between many of them, in particular between countries geographically close. For instance, insecurity in some Sahelian African countries can cause higher inflation in the neighboring countries that are not directly affected by such insecurity ([Noubissi, 2020]). This calls into question the validity of this second instrument. We refrain from using the instruments used by these authors and explore another instrumentation approach to confront their results. The following model is performed to analyze the impact of China's penetration into African markets on African firms' productivity :

$$\ln(TFP_{ikjt}) = \alpha_0 + \alpha china_pen_{ikj(t-1)} + \alpha_1 obst_{ikjt} + \alpha_2 obst_{ikjt} * china_pen_{ikj(t-1)} + \beta X_{ikjt} + \gamma Z_{jt} + D_{kj} + D_{kt} + D_{jt} + \epsilon_{ikjt} \quad (4.1)$$

Where $\ln(TFP_{ikjt})$ represents the natural logarithm of TFP of firm i of industry k at time t , which belongs in country j at time t . Our variable of interest is $china_pen_{ikj(t-1)}$ which represents China's penetration while $obst_{ikjt} * china_pen_{ikj(t-1)}$ represents its interaction term with electricity or financial obstacle. We considered its lag because a firm may take time to respond to Chinese competition. For instance, to invest in capital goods, the theory of enterprise considers one year. This penetration is evaluated following [Dorn, 2020] :

$$china_pen_{ikjt} = \frac{M_{kjt}^{chn}}{Prod_{kj2000} - X_{kj2000} + M_{kj2000}}$$

M_{kjt}^{chn} is the import from China in industry k , country j at time t . In the denominator, we have the economic absorption in the year 2000. It is composed of the part of the industry k production used by the national economy (which is the difference between production ($Prod_{kj2000}$) and export (X_{kj2000}) in industry k and the import (M_{kj2000}) of the industry k products from the rest of the world. The choice of the year 2000 allows for reducing the risk of endogeneity of the variable $china_pen_{ikjt}$. Indeed, we supposed that a country's production in any industry in the year 2000, could not be affected by the Chinese market penetration, since China's trade opening began at the end of 2001.

The variables X_{ikjt} capture firm-level characteristics, including firms' size (*size*), and their exporting status (*Exporter*). The latter takes the value of 1 if a firm exports more than 10% of its production. As for the firm's size, we distinguish small (and medium - SME) from large enterprises. A firm is qualified as 'small' or 'medium' when it has less than 70⁷ employees, in which case the variable *size* takes the value of 0. It takes the value of 1 for large firms. Other firm-level control variables include financial obstacle (*finan_obst*) and electricity obstacle (*elect_obst*). While both variables contain five modalities, we dichotomize them to have a binary variable taking the value of 1 if a firm does face a *major or severe* financial or electricity obstacle, respectively, or 0 when there are no obstacles or they remain minor. We do not consider the

7. Third quartile of "full-time employees" distribution.

case where the obstacle is moderate to avoid any inaccuracy⁸ in the analysis. The interaction term of these variables is also included in the model to take into account the case where both types of obstacles are present simultaneously. The variables Z_{jt} are measured at the country-industry-year level, including penetration in African markets of African countries' main trade partners that are susceptible to compete for both domestic firms and China in local markets. These partners are India and countries that belong to the same free trade agreement area⁹. Finally, we include country-industry D_{kj} fixed effects, as well as country-year D_{jt} and industry-year D_{kt} time-trends in order to control for any other sources of unobserved variability. Given that the sample does not contain many observations, the time variable is categorized into three groups, with the first one covering the years 2005 and 2006, the second covering 2007 and 2008, and the last one covering the years from 2009 to 2018. We recognize that there is no stability in the last period due to the petroleum shock in 2014 and 2016, but in light of the composition of our sample, this classification seems, in our view, better.

The variable capturing China's penetration suffers from endogeneity issues due to at least three reasons. First, there are productive firms that participate more in international trade and are more exposed to import competition from China (i.e. reverse causality). Second, it is possible that firms that remain in the market are more productive and more competitive than those that disappear (i.e. selection bias). Finally, the estimates may also be affected by unobservable characteristics that are correlated with both the exposure to imports from China and firm productivity. Like [Darko, 2021], we follow the approach taken by [Autor, 2013], but modify it slightly by selecting about ten countries in the world that are developing countries¹⁰, and do not have any economic linkage with any African countries. Next, we apply a principal component analysis (PCA) to 12 economic variables¹¹ in order to obtain four variables. Finally, based on these four factors, we match each African country, thanks to the ascending hierarchical classification (AHC), with one or many other countries in our selected countries. Then, the value of the instrument for each country is the average of contemporaneous Chinese penetration in the associated countries for each industry.

4.2 Impact of china's penetration on firms' energy intensity

Most of the previous studies that focused on energy intensity were performed at the macroeconomic level. The variables of interest used were, among others, trade openness, ([Wang, 2021], [Le, 2020]), financial development ([Xue, 2021], [Adom, 2020], [Le, 2020]), and Foreign Direct In-

8. A moderate obstacle is ambiguous and may tend to be a minor obstacle for some companies and a major one for others.

9. Economic Community of West African States (ECOWAS), East African Community (EAC), Southern African Development Community (SADC), Economic Community of Central African States (ECCAS).

10. Cambodia; El Salvador; Honduras; Lao PDR; Moldova; Mongolia; Myanmar; Nepal; Nicaragua and Papua New Guinea.

11. These variables are : are (1) access to electricity in rural areas (% of rural population); (2) access to electricity in urban areas (% of urban population); (3) GDP per capita (constant 2010 US\$); (4) final consumption expenditure (% of GDP); (5) imports of goods and services (% of GDP); (6) oil rents (% of GDP); (7) total natural resources rents (% of GDP); (8) value added in manufacturing (% of GDP); (9) GDP per capita, PPP (constant 2017 international US\$); (10) exports of goods and services (% of GDP); (11) urban population (% of the total population); and (12) sea distance between China and each country.

vestment ([Yaya, 2016], [Hübler, 2010]). Few other studies were performed at the microeconomic level, precisely at the household level ([Hojjati, 2012]; [Vringer, 2000]; [Feng, 2011]) and the firm level ([Zhang, 2020], [Martinez, 2010], [Xue, 2021], [Yang, 2021]). The present analysis is closed in spirit to these papers. [Yang, 2021] applied the Difference-in-Difference method to analyze the effect of trade policy uncertainty defined by China's accession to the WTO on the energy intensity of Chinese manufacturing firms. [Wang, 2021] conducted the same analysis by using mediation models, and regression discontinuity identification strategy in Chinese manufacturing at the industry level. In the same vein, [Adom, 2014] investigated the effects of the change in the trade structure, and technical characteristics of the manufacturing sector on energy intensity in Ghana, using the Phillip-Hansen, Park, and Stock-Watson cointegration models, which are more robust to serial correlation and exogeneity problems. All these papers used different empirical approaches in their empirical works, although they focused mainly on a single country. Our analysis covers additional dimensions. Even if the issue at hand is analyzed at the firm level, the firms concerned do not belong to the same country and were not observed in the same period. This nature of the dataset makes it difficult to choose the appropriate econometric methodology. As productivity and energy intensity are both proxies for firms' performance, we build on equation (1) and postulate the following model :

$$\ln(EI_{ikjt}) = \alpha_0 + \alpha china_pen_{ikj(t-1)} + \alpha_1 obst_{ikjt} + \alpha_2 obst_{ikjt} * china_pen_{ikj(t-1)} + \beta X_{ikjt} + \gamma Z_{jt} + D_{kj} + D_{kt} + D_{jt} + \epsilon_{ikjt} (4.2)$$

where EI_{ikjt} stands for the energy intensity defined as the ratio of electricity cost divided by the firm's sale. Two different measures of electricity cost, and consequently two variables of energy intensity are considered. The first one is the electricity purchased from the network grid, and the second one is the total cost of electricity measured by the cost of electricity purchased from the network grid plus the cost of the fuel used to generate electricity. In addition to the control variables in the model of productivity (equation (1)), we include the share of production lost (*lossper_due_out*) due to the power outage. This model specification suffers also from endogeneity issues since the indicator of energy intensity is calculated using data on enterprise production, while both the latter and Chinese penetration can be influenced by either demand or supply shock. Therefore, we use the same instruments as described above to correct this endogeneity problem.

4.3 Relation between TFP and energy intensity

The impact of productivity on firms' energy intensity has been largely investigated in the literature using different econometric approaches. For example, [Haider, 2020] employed the instrumental variable-generalized method of moments (GMM-IV) to examine the nature of the relationship between TFP and energy intensity in the Indian paper industry. [Sahu, 2016] and [Bagchi, 2020] provided similar analyses, by focusing on all manufacturing sectors, and using the fixed effects approach. [Ladu, 2014] applied a cointegration approach to dynamic panel datasets to analyze the TFP and energy intensity nexus for Italian regions. In other studies, the change in productivity is assimilated to technological change or technological innovation so that TFP

does not appear directly in their model ([Pan, 2019]).

We do not intend to investigate only whether the TFP influences the energy intensity, but to explore whether there exists a bi-directional relationship between these two variables for firms in the African manufacturing sector. Due to the working condition of African firms, it is important to consider the effect of energy efficiency, proxied here by energy intensity, on firms' productivity. This is because according to the literature, electricity is the first obstacle faced by firms. Thus, it is possible that trade competition, including Chinese competition, constrains these firms to invest first in energy efficiency. This type of causality between TFP and EI has been investigated by scholars. For instance, in Kenya's manufacturing sector, [Macharia, 2022] examined empirically the effects of energy efficiency on firm productivity using the generalized method of moments (GMM) estimator for dynamic panel models. The same analysis was performed by [Filippini, 2020] who applied a Difference-in-Difference (DID) model to Chinese iron and steel firms. Likewise, [Haider, 2017] employed a vector error correction mechanism (VECM) to explore the dynamic linkage between energy efficiency and TFP in India. In the cross-countries analysis of the productivity gains of energy efficiency, [Cantore, 2016] applied panel fixed-effects model to 29 low-income countries while a pooled ordinary least squares regression model is applied by [Montalbano, 2019] to a sample of 30 Latin American Caribbean (LAC) states.

In the present analysis, we explore the simultaneous relationship between TFP and energy intensity, by adopting a simultaneous equation model approach. This allows us to take into account all aspects governing the relationship between energy efficiency and productivity in the African context. Based on our theoretical model, we consider the following model :

$$\begin{cases} \ln(EI_{ikjt}) &= \alpha_0 + \alpha_1 \ln(TFP_{ikjt}) + \alpha_2 \text{intk}_{ikjt} + \alpha_3 \log_Va_{ikjt} + X_{ikjt}\lambda + D_{kj} + D_{kt} + D_{jt} + \epsilon_{ikjt} \\ \ln(TFP_{ikjt}) &= \theta_0 + \theta_1 \ln(EI_{ikjt}) + \theta_2 \text{intk}_{ikjt} + \theta_3 \log_Va_{ikjt} + Z_{ikjt}\sigma + D_{kj} + D_{kt} + D_{jt} + \psi_{ikjt} \end{cases}$$

According to the first equation, TFP has an impact on energy intensity while the second captures the inverse relationship. The main explanatory variables identified from the theoretical model are respectively the capital intensity -i.e. the ratio of capital cost to labor cost- (*intk*), and the logarithm of value added (*log_Va*). The production Q included in the theoretical model is replaced by the correspondent value-added while the physical capital stock is replaced by the capital intensity to avoid potential multicollinearity problems. The variables X_{ikjt} and Z_{ikjt} represent control variables while ϵ_{ikjt} and ψ_{ikjt} are error terms in the first and second equations, respectively. By definition, the model suffers from endogeneity issues. Apart from variables that are considered exogenous or predetermined, all dependent variables that appear on the right-hand side are treated as endogenous variables. Further, because some of the explanatory variables are also the dependent variables of other equations in the system, the error terms among the equations are expected to be correlated. The parameters of the system have to be identified in order to estimate the system. According to the order condition rule, the number of exogenous variables¹² not appearing in the first equation must be at least as large as the number of endogenous variables appearing on the right-hand side of the first equation [Wooldridge, 2010],

12. The excluded exogenous variables serve as instruments for the endogenous variable in the first equation and should not be directly related to the dependent variable of this equation.

and vice-versa. The next step is to consider the most appropriate estimation method. Due to the endogeneity issues, namely the correlation between regressors and error terms of each equation of the system, the traditional ordinary least square (OLS) method leads to inconsistent estimated parameters. Available methods that deal with this problem can be classified into two different strategies : single-equation methods and full-system methods [Davidson, 1993]. The former, which includes primarily the 2SLS and Limited-Information Maximum Likelihood (LIML) estimators, estimates the model equation by equation. The full-system methods, of which the main examples are 3SLS and Full-Information Maximum Likelihood (FIML), estimate all the parameters of the model at once. To deal with endogeneity, 2SLS instruments out the endogenous regressors. In the case of the "weak instrument" problem, the alternative technique LIML, introduced by [Anderson, 1949], is warranted. LIML yields invariant¹³ estimates which in many respects have better finite-sample properties than the 2SLS estimator [Davidson, 1993]. However, single equation techniques such as 2SLS and LIML estimators ignore two important issues : correlation between error terms and cross-equation restrictions¹⁴. In contrast, full-system techniques like the FIML and 3SLS estimators in which all the parameters in the model are estimated jointly, take these problems into account and yield more efficient estimates in general. The FIML estimator brings, however, no advantage over the 3SLS estimator, and is much more complicated to implement [William, 2008]. Because the full-system methods require to specify the structure of all equations in the model, misspecification of an equation will, in general, lead to inconsistent estimates of all equations ([Davidson, 1993], [Wooldridge, 2010]). When the sample size is large and heteroskedasticity is severe, the heteroskedasticity three-stage least squares (H3SLS) estimator is likely to be the preferred estimator [Davidson, 1993]. Finally, note that in the event an equation is not identified, that is, there is no instrument for a dependent variable, the single equation method is unable to estimate the system's parameters. The use of the 3SLS method requires, however, some assumptions. For instance, we can make a restriction by equalizing parameters of variables present in both equations of the system or considering that the matrix of variance-covariance of error terms $(\psi_{ikjt}, \epsilon_{ikjt})$ is diagonal [Wooldridge, 2010]. It is also possible to introduce in the identified equation, the combination (square or interaction) of other variables to generate the missing instrument.

5 Data and main variables

In this section, we present the main data that are used to estimate all the above models. The main variables are also presented in detail. Appendix 1 reports for each variable, standard descriptive statistics, including the mean, standard deviation, minimum, and maximum, over the sample.

13. Maximum Likelihood methods yield estimates that are invariant to reparameterization.

14. Sometimes, some systems of equations require that the cross-equation restriction be estimated, which is not possible with a single-equation technique.

5.1 Data

The data on firms used in this study are taken from the database¹⁵ set up by the World Bank to estimate the productivity of firms. Only firms that have been surveyed at least twice are included. In total, there are 2421 firms with 5395 observations in 25 African countries. The database contains all the variables (sales and factors of production) needed to estimate productivity. However, we have supplemented it with energy variables, namely the total costs of electricity and fuel. Following the procedure used by the World Bank, we have adjusted them by removing outliers and deflating them with the GDP deflator (2009) while converting them into dollars according to the fiscal year of each company. Information on Chinese goods imports is extracted from the Base pour l'Analyse du Commerce International (BACI) database of the Centre d'Études Prospectives et d'Informations Internationales (CEPII). Finally, we have extracted from the EORA database, the variables needed to calculate the penetration of Chinese outputs and its instrument. The information is available at the industry level and by country. The manufacturing sector is split into seven specific industries with an eighth industry that includes all unclassified entities. In order to harmonize data in the dataset, taking into account the variety of their sources, we also classified the (2421) companies into eight industries, but only the first seven are considered in our study.

5.2 Explained Variables

5.2.1 Energy Intensity

Energy efficiency can be computed regardless of whether energy is consumed at home, in the office, or in the factory. Since energy exists in several forms and given that there is a diversity of energy use, there are several indicators. Generally, they are defined as the ratio of output to the energy consumed for that purpose, or sometimes the inverse of that ratio. The useful output can be expressed in various units, i.e. units of mass or volume, energy, currency or distance, etc. This is what led [Patterson, 1996] to the categorization of all indicators into four main groups : (purely) thermodynamic, physical-thermodynamic, economic-thermodynamic, or (purely) economic.

- Thermodynamic indicator

Still called enthalpic efficiency, the numerator and denominator of this indicator are expressed in units of energy. The output is energy and the calculation of the two components of the ratio is based either on the first or the second principle of thermodynamics. To do so, it exploits the ambient conditions of the system, i.e. temperature, pressure, the number of molecules, etc. It has the advantage of being useful in thermal processes where there is heat exchange or transfer. However, the information conveyed by this indicator is very technical and is, therefore, not understandable by all energy consumers who are not energy specialists or technicians.

15. World Bank Group, Enterprise Analysis Unit. 2017. "Firm-Level Productivity Estimates". www.enterprisesurveys.org/

- Physical-thermodynamic indicator

Unlike the previous indicator, physical-thermodynamic estimators evaluate the final task of the consumer in a unit that is accessible to him. These units can be kilometer (e.g., distance traveled), ton (e.g., quantity transported or produced). Although the denominator is always expressed in units of energy, any consumer can define or appreciate his utility per unit of energy consumed and thus manage to compare and explain two distinct situations or systems. However, the real problem here is how to define the useful task. For example, consider a company that produces wheat flour from a mill. Let's assume that the mill uses a thermal engine, thus converting thermal energy into mechanical energy represented by a gear system whose rotary motion allows it to crush the raw material that is wheat. In this case, there are three types of useful output, namely the speed of rotation of the system, the quantity of wheat crushed, or the quantity of flour obtained, knowing that each of these variables can be influenced by other factors endogenous or exogenous to the whole production system.

- Economic-thermodynamic indicator

Like the traditional productivity of labor or capital, the economic-thermodynamic indicator represents the productivity of energy. The latter is useful at the macroeconomic level because it allows us to know the gross output of an economy per unit of energy consumed. The fact that useful output is expressed in monetary units is a limitation in terms of its use to compare two economies with different currencies since the exchange rate does not incorporate the purchasing power of each of these currencies in their respective economies, and this can bias a comparative analysis. However, to overcome these shortcomings, [Reister, 1987] suggests calculating GDP in purchasing power parity.

- Economic Indicator

Here, the two components of the indicator are evaluated in monetary units. It has the advantage of taking into account economic realities and facilitating comparison between countries since it is dimensionless. However, it does not truly reflect the energy efficiency of either a country or an industry. Indeed, at the company level, the value of the indicator may change not because the company's energy consumption has changed but because the energy price or the market price of the output has varied. However, in an econometric analysis, including these control variables makes it possible to rule out the influence of these economic contingencies.

- Choice of indicator

The thermodynamic indicator seems to be more objective than all the others because it does not depend on the economic variables so it is easy to compare the energy efficiency of a system over time. This last aspect is also appropriate for the physical-thermodynamic indicator, provided that the same output is maintained over time. Similarly, the comparison between any two countries is also easy with these two indicators. However, the physical-thermodynamic indicator is less adapted to our case as we are working on a sample of different types of enterprises

whose outputs are not expressed in the same unit. Likewise, the fact that these indicators do not take into account the type (or quality) of energy used can also bias the comparison of the energy efficiency of two systems powered by two different types of energy. Another problem is the allocation of energy in the case of multi-product companies. Indeed, when the company produces several goods, it is difficult to know the quantity of energy consumed by each of these goods. This is especially true for thermodynamic and physical-thermodynamic indicators. As for the other types, provided that the two products are separable, a simple approach would be to allocate the energy consumed on a pro-rata basis according to the share of each product, for example, in turnover of a firm, or by using an econometric approach ([Cleland, 1981], [Rao, 1981]).

Summing up, as we work on companies belonging to different sectors and different countries, a pure indicator is more appropriate than a hybrid energy intensity indicator. The pure thermodynamic indicator is very difficult to evaluate when the direct output of the company is not energy, whereas the economic indicator can be adapted to all types of companies, whatever their output. It follows that the latter is the most suitable and is therefore retained for the rest of our study. Moreover, the economic indicator has been widely used in the literature by different authors in various analyses. Although it does not exactly reflect the energy efficiency of a process or a company, it at least partially takes into account the quality of the energy source because the more environmentally friendly it is, the more expensive it is, and the better the system that consumes it. Then comes the question of the choice of energy source to consider. Factories generally use two sources of energy : electricity and petroleum products such as gas, gasoline, diesel, and heavy fuel oil. While electricity is ubiquitous in all businesses regardless of their nature or industry, petroleum products are not, and they differ widely in quality and characteristics. It follows that the most plausible choice would be electricity. However, since heat is essentially cheaper to produce with petroleum products, this choice would be detrimental if several firms used this energy (heat) in their production process. In conclusion, we retain (pure) economic indicators whose inverse is called energy intensity, and electricity as the main energy source of production.

5.3 Explanatory variables

5.3.1 Total Factor Productivity

Consider the following standard production function

$$Val_Ad_{ijt} = \alpha_0 + \alpha_k.K_{ijt} + \alpha_l.L_{ijt} + \omega_{ijt} + \Psi_{ijt} \quad (4.3)$$

where K (natural logarithm of capital) and L (natural logarithm of labor cost) are the main factors of production. The left-hand side variable is the natural logarithm of the value added in production (Val_Ad). The error term is decomposed into two components that are productivity ω_{ijt} and idiosyncratic error Ψ_{ijt} . The latter is known by both producer and econometrician while only the producer knows the former. This leads the producer to increase (or decrease) the input when productivity increases (decreases) so that the input can be adjusted according

to the dynamic of the productivity. Consequently, there is an endogeneity issue. To address this endogeneity issue, many papers in the literature used resorted to the GMM (Generalized Method of Moments) approach ([Arellano, 1991]; [Arellano, 1995]; [Blundell, 1998]; [Arellano, 2001] ([Elu, 2010])), fixed-effects panel methods ([Mundlak, 1961], [Hoch, 1962]), instrumental variable (IV) method ([Akerberg, 2007], [Lu, 1999]) or input control approaches like that of [Levinsohn, 2003] (LP) which is based on that of [Olley, 1992] (OP). In our case, the fact that our panel dataset covers only two periods makes it difficult to use the GMM method. The panel fixed-effects approach assumes that firms' productivity does not change across time, but this is a strong assumption since productivity is very sensitive, and changes according to several parameters such as input quality ([Fox, 2011], [Halpern, 2005]), firm size ([Dhawan, 2001]) which can itself, change over time. As for the instrumental method, the instruments used are input prices, which can vary across firms, and are rarely available. Concerning the LP and OP approaches, it is important to note two fundamental concerns. These methods are applied on only one sector¹⁶ in only one country,¹⁷ thereby allowing to make the assumption that all firms belonging to each sector face the same market conditions. Other scholars used non-parametric methods [Hall, 1990] where the production function parameters that are also the output-input elasticities are calculated as the share of input's cost relative to the total cost. This calculation is performed for each input at the industry level before inferring the productivity at the firm level by a simple difference. However, this approach is based on the assumptions of constant return and perfect competition in the market. Few studies have analyzed cross-country productivity at the firm level. [Şeker, 2018] made a cross-country analysis of TFP on a sample of 69 countries and about 19787 firms. They applied the non-parametric approach of [Hall, 1990] to the trans-log production function.¹⁸ They first determine the model's parameters and then compute the productivity at firm levels before aggregating them by the industry for each country. To check whether China transfers productivity-enhancing technology to Sub-Saharan African manufacturing firms in the context of the Sino-African trade, [Elu, 2010] used the GMM method to evaluate the effect of the Sino-African trade on manufacturing firms' productivity in five countries using data from CSAE¹⁹ Centre for the Study of African Economies (CSAE) at Oxford University. [Darko, 2021] used LP's approach to perform the same analyses. To respect the assumptions of this approach, they estimated productivity by industry and by country for all firms using the Enterprise Survey Data from World Bank.

In this paper, we also use the LP's approach. [Levinsohn, 2003] used intermediate goods to correct endogeneity while [Olley, 1992] used investment. Since very few companies have made investments in our database, it would be advantageous to use the former approach in order to exploit the maximum possible observations of our data. Following [Darko, 2021], we estimate the productivity at the firm level, by each industry-country group.

16. *Telecommunication* in the case of [Olley, 1992] and *manufacturing industries*. (Food products, Metals, Textiles, and Wood products, separately)

17. USA for [Olley, 1992] and Chile for [Levinsohn, 2003].

18. This function does not impose constant elasticities of production factors but they are not monotonic like in the Cobb-Douglas model and are harder to interpret.

19. .

Presentation of Levinsohn and Petrin (2003) method

The estimation method of the production function developed by LP is applicable when the dependent variable is *revenue* (price multiplied by quantity) or *value added* (revenue minus intermediate input). The latter is used in this paper. It is based on three major conditions that are described below. Let's consider our production function in equation (1). The first condition stems from the endogeneity problem mentioned above, that is, the fact that the company increases its intermediate inputs as its productivity increases conditionally to its capital stock level. We translate this phenomenon into the following equation :

$$i_t = f_t(k_t, \omega_t) \quad (4.4)$$

where i_t is the intermediate input (material) and f_t represents the demand function of intermediate inputs. According to the separability condition, the production technology must be separable in the particular input that is used as a proxy.

The condition denoted as *monotony condition* stipulates that i_t must strictly increase in function of productivity. We need this condition in order to invert f_t and obtain ω_t as a function of k_t and i_t . Note that the demand function is indexed by t to take into account the change in intermediate input price over time, which is common across all firms in a given industry. This leads to the second condition denoted *perfect competition condition*, which stipulates that firms in the same industry must belong to the same market, and hence face the same input and output prices.

So,

$$\omega_t = f_t^{-1}(k_t, i_t) = w_t(k_t, i_t) \quad (4.5)$$

(3) in (1) gives

$$Val_Adj_{ijt} = \alpha_l \cdot L_{ijt} + \Phi_t(k_t, i_t) + \Psi_{ijt} \quad (4.6)$$

with

$$\Phi_t(k_t, i_t) = \alpha_0 + \alpha_k \cdot K_{ijt} + w_t(k_t, i_t)$$

Besides controlling for endogeneity, another advantage of this method²⁰ also lies in the fact that it gives exclusively positive values, unlike other methods such as the GMM and panel fixed-effects.

5.3.2 China's penetration

The calculation of the Chinese penetration in the domestic market of African countries requires variables such as imports from China and absorption in the domestic economy. The former is directly extracted from the BACI database, while the latter is determined thanks to

20. Further details on this estimation method could be found in [Levinsohn, 2003].

the EORA database. In fact, production, exports, and imports are available at the industry level, and this makes it possible to calculate the absorption in the domestic economy in the year 2000.²¹ Since the numerator (of this variable) varies from one year to the other, it is better to use the BACI database because its values are observed, and are therefore closer to reality than those of EORA, whose values are based on estimates. Nevertheless, the EORA Database has been used in many academic studies. The instrument is constructed following [Autor, 2013] and measures the penetration of China in economically similar countries to those in our sample that is concerned.

5.3.3 Financial development

A country's finance is multi-faceted and cannot be grasped by a single variable. This explains why the World Bank and the IMF have released several indicators²² to better assess the financial system of a country. Many papers have measured financial development by using bank credit to the private sector as a percentage of GDP, the ratio of total bank assets to GDP, and stock market capitalization in the percentage of GDP ([Xiao, 2012], [Arellano, 2012], [Demirguc-Kunt, 2008]). Similarly, past financial crises have highlighted the significant role of non-bank financial institutions and thus led to using total financial assets to GDP as an alternative proxy ([Cheng, 2010], [Liang, 2012], [Rateiwa, 2017]). However, these indicators do not provide information on the accessibility and efficiency of these institutions, nor do they incorporate financial market characteristics. To fill this gap and exploit a large amount of data available concerning the financial system, [Čihák, 2012] developed several measures of four characteristics of financial institutions and markets, namely (a) the size of financial institutions and markets (financial depth), (b) the degree to which individuals can and do use financial institutions and markets (access), (c) the efficiency of financial institutions and markets in providing financial services (efficiency), and (d) the stability of financial institutions and markets (stability). The authors recognize that financial depth, access, efficiency, and stability might not fully capture all features of financial systems and they make no attempt to construct a single composite index of financial systems. However, based on the first three characteristics, [Svirydzenka, 2016] proposed to aggregate in a pyramidal form a single index of financial development.

Moreover, in developing countries, especially in African countries, the financial sector is poorly developed, which has led many researchers ([Jalilian, 2002], [Dawson, 2008], [Perez-Moreno, 2011]), to favor the traditional indicator of the ratio of bank credits to GDP, despite its limitations. Given that the analysis in this paper is at the firm level, we construct our variable measuring the level of financial constraints faced by firms as the level of the financial obstacle, perceived as such by the firm manager ([Sleuwaegen, 2002]). This information is available in the Enterprises Survey Data of the World Bank's Database. [Harrison, 2014] also used the same indicator, but pointed out that it is likely endogenous. They then interact its mean, at the city level, with the size of the firm to reduce the endogeneity of the variable. The financial development

21. The production value is only available in the EORA database. Now, whether we used the import and export values from BACI or EORA to calculate the absorption does not make a significant difference in the results.

22. See worldbank.org/financialdevelopment and <http://data.worldbank.org/datacatalog/global-financial-development>.

indicators will be used as a robustness check.

6 Empirical Results

The following sections present the main result of the empirical analysis. The first two sections assess the effect of Chinese imports on firms' productivity and energy intensity, respectively. The last section reports the results of the simultaneous analysis between productivity and energy intensity.

6.1 China's penetration and firm productivity

China's influence on firms' African firms' TFP is analyzed through different angles that are presented in Table 4.1. We, first, present the results using the use of the OLS estimator and then display the results of the model specification estimated using the instrumental variable (IV) estimator. In all these models, the TFP is expressed in logarithm. Although the OLS estimation suggests that China's penetration has no statistically significant effect on firms' productivity, the IV estimations show a significant and negative effect of Chinese penetration on firms' productivity. Failing to address the endogeneity of China's penetration variable leads to biased results. We estimate each model on the full sample and on the sub-sample of small (and medium) enterprises and of large enterprises separately. Model 1 specification includes China's penetration, the main trade partner penetrations, the firm's size, and its exporting status. Model 2 includes the electricity obstacle variable, while Model 3 includes the finance obstacle variable. Model 4 includes both electricity and finance obstacle variables. The interaction of both variables is included in Model 5 (see Table 4.1).

TABLE 4.1 – Impact of China's penetration on firms' productivity

	log_tfp - OLS	log_tfp - IV										
	Full	model 1			model 2			model 3			Model 4	Model 5
		Full	Small	Large	Full	Small	Large	Full	Small	Large	Full	Full
china_pen1	-0.013 (.001)	-0.009* (0.005)	-0.012** (0.006)	-0.006 (0.009)	-0.012* (0.006)	-0.015* (0.008)	-0.009 (0.011)	-0.013** (0.006)	-0.017** (0.008)	-0.016* (0.009)	-0.021** (0.009)	-0.021** (0.009)
india_pen1	0.001 (.008)	0.008 (0.009)	0.014 (0.009)	-0.171** (0.069)	0.009 (0.009)	0.012 (0.008)	-0.102 (0.070)	-0.001 (0.009)	0.006 (0.009)	-0.059 (0.089)	0.004 (0.010)	0.003 (0.010)
fta_pen1	-.004 (.002)	-0.005* (0.003)	-0.006* (0.003)	-0.076*** (0.025)	-0.006* (0.003)	-0.006* (0.003)	-0.066* (0.036)	-0.004 (0.003)	-0.007** (0.003)	-0.026 (0.042)	-0.005 (0.004)	-0.006 (0.004)
exporter	.234*** (.070)	0.256*** (0.079)	0.220* (0.117)	0.270*** (0.098)	0.232*** (0.075)	0.214** (0.109)	0.229** (0.107)	0.247*** (0.081)	0.234** (0.117)	0.216* (0.111)	0.284*** (0.091)	0.290*** (0.091)
size	.326*** (.063)	0.287*** (0.070)			0.321*** (0.068)			0.350*** (0.074)			0.357*** (0.083)	0.354*** (0.083)
elect_obst					-0.110 (0.087)	-0.068 (0.099)	-0.207 (0.152)				-0.209** (0.104)	-0.164* (0.095)
elect_obst*china_pen1					0.010** (0.005)	0.014** (0.005)	0.006 (0.009)				0.0167*** (0.006)	
finan_obst								-0.138** (0.070)	-0.183** (0.082)	-0.121 (0.138)	-0.161* (0.082)	-0.117 (0.074)
finan_obst*china_pen1								0.008* (0.004)	0.008 (0.005)	0.020** (0.009)	0.010* (0.005)	
0.finan_obst*1.elect_obst*china_pen1												0.019*** (0.007)
1.finan_obst*0.elect_obst*china_pen1												0.015** (0.007)
1.finan_obst*1.elect_obst*china_pen1												0.018** (.008)
constant	.007*** (.002)	0.032 (0.033)	0.061* (0.036)	3.234*** (0.433)	0.090 (0.066)	0.059 (0.075)	3.182*** (0.560)	0.106** (0.051)	0.139** (0.060)	3.336*** (0.614)	0.285** (0.111)	0.220** (0.094)
Observations	1650	1,337	947	390	1,390	993	397	1,650	892	348	1,055	1,055
R-squared		0.849	0.862	0.853	0.857	0.875	0.832	0.849	0.859	0.850	0.853	0.855
IV F-stat		184.3	124	53.40	124.4	74.70	52.25	200.7	77.22	26.96	65.65	76.83

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

All these models show a significant and negative effect of China's penetration on firms' productivity in the full sample and for small (and medium) enterprises. Large firms do not seem to react to China's competition by increasing their productivity. India's penetration in African countries' markets does not affect firms' productivity, apart from Model 1 where the coefficient of the related variable is negative and statistically significant on large firms. However, the latter finding is not sufficient to deduce that imports from India represent a threat to African firms. The penetration of FTA members in African markets has, sometimes, exerted a significant negative impact on African firms' productivity, but the estimate is no longer statistically significant when all control variables are taken into account. This instability in the estimates prevents us from concluding that FTA members represent a threat to African firms. Table 4.1 also shows that the firm's size and its exporting status have a strong positive and statistically significant effect on its productivity. That means that larger firms and exporting firms tend to have high productivity. This is in line with several papers, such as [Bernard, 2004] and [Melitz, 2003]. While the electricity obstacle does not affect firms' productivity in Model 2, Model 3 reports that finance's obstacle reduces firms' productivity. Both model specifications suggest that when firms face electricity or financial obstacles, they further improve their productivity, as China's penetration in the market increases. This counter-intuitive result is confirmed in Models 4 and 5 where both obstacles have a negative statistically significant effect on firms' productivity but to a lesser extent for finance's obstacle than for the electricity obstacle in the last model. This can

be explained by the fact that electricity continues to be an obstacle for an enterprise when it also faces finance's obstacles. Hence, financial obstacles information is partly taken into account by the existence of electricity obstacles. According to these results, African countries that face market failures in the electricity and financial sectors do not care about these obstacles in the absence of (foreign) threats in the local market. More precisely, these results show that china's penetration provides incentives to SMEs to improve their TFP when they face electricity obstacles, but not when they face financial obstacles. It seems that it is much more difficult for firms to overcome financial obstacles than electricity obstacles. Contrary to SMEs, China's penetration does not seem to incentivize large firms to improve their productivity when they face electricity obstacles. In contrast, China's penetration leads to an improvement in large firms' productivity when these firms face financial obstacles. This result can be explained by the fact that electricity is not a big obstacle for large enterprises because, in the presence of a power outage, they can use profitably a generator due to economies of scale. That is not obvious for SMEs that, perhaps, have to wait for better market competition to make this investment. Also, large enterprises can more easily overcome financial obstacles and make investments to improve their productivity ([Beck, 2006b]). However, these results continue to be puzzling because they show that the average impact of China's penetration on firms' productivity in the full sample is negative, while (small) firms that face electricity obstacles improve their productivity. This finding is puzzling and runs against results largely found in the literature. But we can be tempted to argue that these findings are specific to the case of China's penetration into African markets.

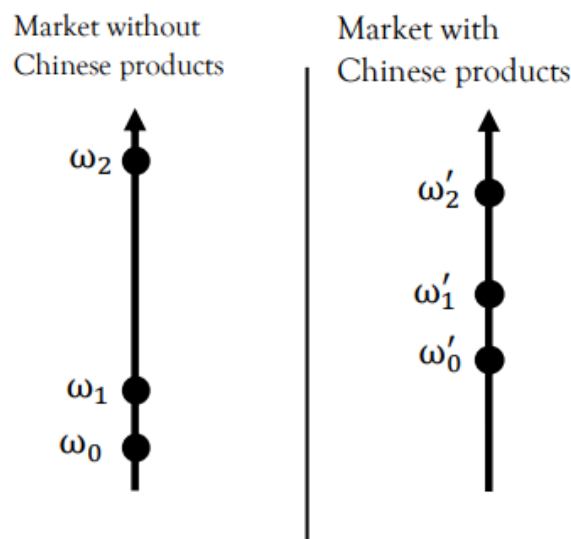


FIGURE 4.4 – Productivity movement before and after China's entry into the African market

Let us consider two periods of time and both are separated by China's trade openness date (i.e 2001). Let us also assume that they are two types of enterprises in the market : firms that face either electricity obstacle or finance obstacle with productivity ω_1 , and other firms that face none of these obstacles, with productivity ω_2 . Suppose that the minimum productivity to stay

in the market is ω_0 . The presence of these two types of enterprises in the market means that $\omega_1 > \omega_0$ and $\omega_2 > \omega_0$ (Figure 4.4). Suppose that after China's trade opening, the threshold of productivity increases and becomes ω_0' due to the Chinese competition that reduces the market price. The lower the price, the greater the need for firms to increase their productivity to sell at this price. Hence, to continue to stay in the market, firms have to invest to improve their productivity. Based on our results, we can argue that firm that faced obstacles (before China's entry African market) which undermined their productivity, would try to overcome these obstacles by improving their productivity (from ω_1 to ω_1') in order to stay in the market. More precisely, in order to improve their productivity when facing Chinese competition in the local markets, African SMEs struggle to solve their electricity problem and large enterprises bargain to access finance. SMEs that experience financial obstacles fully undergo the shock.

According to our results, firms that do not face any substantial obstacle do not undertake any action to improve their productivity. This means that they do not wait for competition (including from China) to improve their productivity. Conversely, because the overall impact is negative for SMEs, the productivity of firms that do not face any obstacle decreases (from ω_2 to ω_2') when these firms face competitive pressure from China's imports. Although difficult to explain, these findings may reflect the fact that the competition from China is not only based on prices. Indeed, China is a particular trading partner able to adapt to the market conditions of the host countries. As the purchasing power of consumers in developing countries is low, China could supply low-quality goods (although of a higher quality than similar local products) at a price lower than the one prevailing in the local market of the host country. For example, [Gebre-Egziabher, 2007] found that China's penetration in the Ethiopian's textile sector led to a reduction in Ethiopian firms' production due to its low product price but also led to better product quality, mainly for firms that struggle to stay on the market. We can infer that apart from resolving traditional problems, African firms have to make innovations to face the import competition from China. If firms are efficient, but their products are not wanted by local consumers, their efficiency would not bring them any advantage, but would instead result in a loss of market share and consequently a loss in their productivity.

6.2 China's penetration and firm's energy intensity

The effect of china's penetration on the firms' energy intensity is presented in Tables 4.2 and 4.3. The indicator of firms' energy intensity used in 4.2 takes into account only electricity purchased from the network grid while the indicator of firms' energy intensity used in 4.3 is calculated using the total cost of electricity.

Table 4.2 shows that China's penetration does not affect firms' energy intensity. In fact, once the endogeneity is corrected, the coefficient becomes statistically significant and negative, but the significance disappears when we add control variables even if in the last two model specifications, the impact of China's penetration on African firms' energy intensity is negative and slightly statistically significant. This means that China's penetration leads to a slight decrease in energy intensity. Even though India's penetration is positive and statistically significant in the last two model specifications, it is not statistically significant in the previous model specifications. It is

the same for other FTA members' penetration that shows no statistically significant coefficients in all models. Results also show that being an exporting firm does not have a statistically significant effect on energy consumed per unit produced, while being a larger firm lowers energy intensity, perhaps due to economy of scale. All model specifications show a large statistically significant effect of the loss due to outage on energy intensity, but only for SMEs. This suggests that once the products are made, the absence of energy leads to a loss of part of the production due maybe to a depreciation of goods produced. This is likely the case for the agro-industry where product conservation is indispensable because products are perishable. In this case, the fact that all output is not sold in the market leads to a higher energy intensity. This reveals a limit to using the pure economic indicator of energy intensity to proxy for energy efficiency. Even if a firm is energy efficient, it can have a high energy intensity given the way it is calculated. Finally, the estimation shows that both financial and electricity obstacles do not lead African firms to invest in energy efficiency even in the presence of competitive pressure from imported Chinese products.

TABLE 4.2 – Impact of China's penetration on firms' energy intensity

	log_ei - OLS	log_ei - IV										
	Full	model 1			model 2			model 3			Model 4	Model 5
		Full	Small	Large	Full	Small	Large	Full	Small	Large	Full	Full
china_pen1	0.000 (.000)	-0.001** (0.000)	-0.000 (0.000)	0.003 (0.003)	-0.002 (0.001)	-0.000 (0.000)	-0.057 (0.644)	-0.002 (0.002)	-0.001* (0.001)	0.001 (0.003)	-0.001* (0.001)	-0.001* (0.001)
india_pen1	.000 (.000)	-0.000 (0.000275)	-0.000 (0.000)	-0.004 (0.004)	0.000 (0.000)	0.000110 (0.000)	0.028 (0.320)	0.001 (0.001)	0.000 (0.000)	-0.001 (0.004)	0.001** (0.000)	0.001** (0.000)
fta_pen1	.000 (.000)	-0.000 (0.000)	-0.000 (0.000)	0.001 (0.001)	-0.000 (0.000)	0.000 (0.000)	-0.013 (0.159)	-0.000 (0.000)	-0.000 (0.000)	0.001 (0.001)	-0.000 (0.000)	-0.000 (0.000)
exporter	-.002 (.003)	-0.002 (0.003)	-0.005 (0.003)	0.001 (0.007)	-0.006 (0.004)	-0.004 (0.004)	-0.184 (1.955)	0.001 (0.005)	-0.004 (0.004)	0.005 (0.008)	-0.002 (0.004)	-0.00153 (0.004)
size	-.005** (.002)	-0.008*** (0.003)			-0.009** (0.004)			-0.009* (0.005)			-0.011*** (0.004)	-0.011*** (0.004)
lossper_due_out	.0003*** (.0001)	0.0004*** (0.0001)	0.0004*** (0.0001)	-0.000 (0.0003)	0.0003** (0.0001)	0.0004*** (0.0001)	0.000 (0.003)	0.0004** (0.0001)	0.0004*** (0.0001)	-0.0002 (0.0005)	0.0003*** (0.0001)	0.0003*** (0.0001)
elect_obst					-0.026 (0.019)	0.005 (0.004)	-0.616 (6.965)				-0.009 (0.007)	-0.011 (0.007)
elect_obst*china_pen1					0.001 (0.001)	-0.000 (0.0002)	0.026 (0.289)				0.001 (0.0003)	
finan_obst								-0.027 (0.0258)	-0.002 (0.00524)	0.007 (0.024)	-0.007 (0.005)	-0.007 (0.005)
finan_obst*china_pen1								0.002 (0.001)	0.0004 (0.0002)	-0.0004 (0.001)	0.001* (0.0003)	
0b.finan_obst*1.elect_obst*china_pen1												0.001 (0.001)
1.finan_obst*0b.elect_obst*china_pen1												0.001 (0.001)
1.finan_obst*1.elect_obst*china_pen1												0.001 (0.001)
Constant	.014*** (.004)	0.016*** (0.004)	0.014*** (0.004)	0.051 (0.038)	0.033** (0.017)	0.007 (0.005)	0.643 (7.002)	0.039* (0.021)	0.019*** (0.006)	0.043 (0.035)	0.0264*** (0.009)	0.0270*** (0.009)
Observations	2,368	2,368	1,738	630	1,903	1,398	505	1,761	1,274	487	1,421	1,421
R-squared			0.337			0.354			0.279	0.032	0.072	0.051
IV F-stat		13.02	72.59	5.212	10.26	52.96	0.033	4.932	35.11	0.976	13.48	12.10

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

The results using the total cost of energy show a more pronounced negative and statistically significant negative impact of trade competition from China on the local market for SMEs. But this decrease in energy intensity can have many explanations. For example, due to Chinese

competition, a firm can reduce its capital intensity so as to reduce its energy cost even if it becomes less productive. Likewise, based on our theoretical model, the logarithm relationship between energy intensity and production suggests that a slight fall in the production of SMEs leads to a large reduction in energy intensity. It follows that the competitive effect of China on SMEs can lower their energy intensity, *ceteris paribus*. Other trading partners also influence significantly firms' energy intensity but to a lesser extent. There is no statistically significant effect of being an exporting firm on the firm's energy intensity while being a larger enterprise can reduce its total energy intensity. The loss due to the power outage continues to increase the firm's energy intensity. This means that the use of an electrical generator does not help firms reduce their energy intensity. Compared to the case of electricity intensity, there may be a compensatory effect here, namely, the use of a generator reduces the loss of the quantity produced but may increase the energy costs due to the purchase of diesel.

We note from the results reported in Table 4.1 that large enterprises that are confronted with financial obstacles make the investment to improve their productivity in the context of competitive pressure from China. This should lead to a change in energy intensity. At the same time, the results reported in Table 4.3 do not show a statistically significant effect of the interaction term between finance obstacle and China's competition on energy intensity. This result can also be explained by the logarithm relationship between energy intensity and production level according to the theoretical model described above. For higher values of production, a large increase of production is associated with a small increase in energy intensity, *ceteris paribus*. Table 4.1 also shows that the productivity of SMEs that are confronted with financial obstacles does not increase under the competitive pressure from China, while firms confronted with electricity obstacles increase it. According to the results in Table 4.3, the energy intensity increases for SMEs that are confronted with financial obstacles. Hence, we can deduce that SMEs that are likely confronted with both electricity and finance obstacles struggle only to get the necessary finances to purchase generators when they face competitive pressure from China.

In the last model specification, the positive sign of the interaction terms suggests that regardless of whether firms face financial obstacles, electricity obstacles, or both, Chinese import competition leads to an increase in their energy intensity. This confirms that the impact is more significant when firms are confronted with both types of obstacles.

TABLE 4.3 – Impact of China’s penetration on firms’ total energy intensity

	log_tei - OLS			log_tei - IV								
	Full	model 1			model 2			model 3			Model 4	Model 5
	Full	Full	Small	Large	Full	Small	Large	Full	Small	Large	Full	Full
china_pen1	-0.000	-0.001**	-0.001*	0.006	-0.002*	-0.001	-0.008	-0.002*	-0.001**	0.009	-0.002**	-0.002**
	0.000	(0.000)	(0.0003)	(0.009)	(0.001)	(0.0005)	(0.011)	(0.001)	(0.001)	(0.187)	(0.001)	(0.001)
india_pen1	0.000	-0.0001	-0.000	-0.007	0.0002	-0.0001	0.003	0.001*	0.001	-0.011	0.001**	0.001*
	(0.0002)	(0.0003)	(0.0003)	(0.009)	(0.0003)	(0.0003)	(0.006)	(0.0007)	(0.0003)	(0.208)	(0.0003)	(0.0003)
fta_pen1	-0.0001	-0.0006*	-0.0003	0.002	-0.0003	-0.0002	-0.0009	-0.0005**	-0.0005**	0.0025	-0.0004*	-0.0005**
	(0.0002)	(0.0003)	(0.0002)	(0.002)	(0.0002)	(0.0002)	(0.002)	(0.0002)	(0.0002)	(0.042)	(0.0002)	(0.0002)
exporter	0.0002	0.0008	-0.002	0.005	-0.003	-0.000	-0.029	0.005	0.0004	0.026	0.003	0.004
	(0.003)	(0.003)	(0.004)	(0.012)	(0.005)	(0.005)	(0.036)	(0.005)	(0.005)	(0.428)	(0.005)	(0.005)
size	-0.004	-0.008**			-0.012**			-0.009**			-0.014***	-0.014***
	(0.003)	(0.003)			(0.005)			(0.004)			(0.005)	(0.005)
lossper_due_out	0.0003***	0.0004***	0.0004***	-0.0002	0.0002*	0.0003***	0.000	0.0004***	0.0004***	-0.001	0.0003**	0.0003**
	(0.000)	(0.0001)	(0.0001)	(0.001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0001)	(0.0233)	(0.0001)	(0.0001)
elect_obst					-0.0334	0.0007	-0.0632					
					(0.0209)	(0.0056)	(0.110)				(0.009)	(0.010)
elect_obst*china_pen1					0.002*	0.0002	0.0033				0.001*	
					(0.001)	(0.0002)	(0.005)				(0.0005)	
finan_obst								-0.0269	-0.005	0.069	-0.012*	-0.013*
								(0.018)	(0.006)	(1.375)	(0.007)	(0.007)
finan_obst*china_pen1								0.0015	0.001**	-0.003	0.001**	
								(0.001)	(0.0003)	(0.0605)	(0.0004)	
0b.finan_obst*1.elect_obst*china_pen1												0.0013*
												(0.001)
1.finan_obst*0b.elect_obst*china_pen1												0.0014*
												(0.001)
1.finan_obst*1.elect_obst*china_pen1												0.002**
												(0.001)
Constant	0.021***	0.023***	0.021***	0.059	0.046**	0.018**	0.085	0.046***	0.029***	-0.038	0.044***	0.046***
	(0.005)	(0.005)	(0.005)	(0.054)	(0.018)	(0.007)	(0.110)	(0.015)	(0.007)	(1.900)	(0.013)	(0.014)
Observations	2,374	2,374	1,744	630	1,910	1,405	505	1,768	1,280	488	1,430	1,430
R-squared	0.306		0.341			0.350			0.294			
IV F-stat		14.05	73.35	1.819	13.34	51.01	2.478	7.997	37.57	0.009	14.75	12.74

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

6.3 Productivity and energy intensity

We started this analysis by using the single equation approach with the 2SLS model (Table 4.4) before moving to the 3SLS estimator (Table 4.5). In the former, we instrument energy intensity by the variable *lossper_due_out* because it is strongly correlated with energy intensity but not correlated with the dependent variable, *productivity*. For the latter, it is complicated to find an instrument that would respect the key conditions. Based on the literature, the firms’ productivity is correlated with the firm’s size that is large firms tend to have high productivity, as observed in Table 4.1. According to Tables 4.2 and 4.3, the energy intensity is also strongly correlated with the firm’s size. Despite this, we used the firm’s size as an instrument for productivity (no other instrument is available), but in different ways. We use it in categorical form (*size*) and in continuous form. Instead of choosing the firm’s total size, we retain only the number of skilled employees (*skill*) as they are likely to have more impact on the firm’s efficiency. The number of skilled employees is also interacted with the capacity utilization rate (*cur*) because firms that have the same size and do not use their equipment at the same level may have very different productivities. The results are presented in Table 4.4. The variable *lossper_due_out* is strongly correlated with energy intensity. Likewise, the variables *size* and *skill* are also si-

gnificantly correlated with the productivity variable but with an unexpected negative sign. We have to be cautious when interpreting the outcomes related to these variables.

TABLE 4.4 – Relationship between energy intensity and productivity (2SLS approach)

VARIABLES	log_tfp	log_tfp	log_tfp	log_tei	log_tei	log_tei
log_tfp				-0.030**	-0.023**	-0.022**
				(0.014)	(0.010)	(0.009)
log_tei	7.296	2.260	2.714			
	(7.240)	(12.36)	(12.40)			
log_va	0.267***	0.346***	0.353***	0.003	0.002	0.002
	(0.039)	(0.075)	(0.075)	(0.003)	(0.003)	(0.003)
intk	-0.072	0.231***	0.233***	0.002	0.001	0.001
	(0.076)	(0.063)	(0.064)	(0.002)	(0.003)	(0.003)
cur	0.003*	0.0003	0.001			
	(0.001)	(0.002)	(0.002)			
size	-0.262***					
	(0.086)					
lossper_due_out				0.0004***	0.0003**	0.0003**
				(0.0001)	(0.0001)	(0.0001)
skill		-0.001***	-0.001			
		(0.0004)	(0.0004)			
cur*skill			-0.000			
			(0.000)			
Constant	-3.059***	-4.300***	-4.423***	-0.012	0.002	0.003
	(0.583)	(1.282)	(1.290)	(0.036)	(0.039)	(0.038)
Observations	1,099	868	868	1,127	886	868
R-squared	0.885	0.931	0.930	0.004	0.125	0.140
Instruments						
lossper_due_out	.0004**	.0003*	.0003*			
	(.002)	(.002)	(.002)			
size				-.209***		
				(.071)		
skill					-.0011***	-.001
					(.0003)	(.0004)
cur						.001
						(.002)
skill*cur						-0.000
						(0.000)
IV F-stat	11.38	4.078	4.073	18.53	28.08	9.683

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 ; all models include dummy country*time, industry*time and country*industry variables.

According to the estimation results, a rise in firms' productivity leads to a fall in energy intensity, while the latter does not affect significantly the former. Apart from the weakness of the instruments for productivity, these results are not surprising. As shown theoretically, energy intensity and productivity are inversely correlated. But the empirical results show that the causality seems to go in one direction only, namely from productivity to energy intensity. If we refer to our theoretical model, we can argue that, perhaps, the increase in energy intensity is due to the increase in both production and installed physical capital, so that through an offsetting effect, the energy intensity ultimately exerts no significant effect on productivity. On another note, added value and capital intensity variables affect positively and statistically significantly firms' productivity but not firms' energy intensity. The loss due to outage (*lossper_due_out*) and the firm's size as well as its interaction with the capacity utilization rate have the same signs as in the first stage.

As the 3SLS-estimator ignores the quality of the instrument but requires good specification and respect for identification rules, we have used the previous instruments to estimate the structural equation modeling (SEM) with this estimator. Results in Table 4.5 indicate that firms' energy intensity does not affect statistically significantly their productivity, but the latter reduces statistically significantly the energy intensity. All other variables have maintained their sign and remain statistically significant except for the capital intensity indicator.

In sum, the analysis suggests that the relationship between African firms' energy intensity and productivity runs mainly from productivity to energy intensity.

TABLE 4.5 – Relationship between energy intensity and productivity (3SLS approach)

VARIABLES	model 1		model 2		model 3		model 4	
	log_tfp	log_tei	log_tfp	log_tei	log_tfp	log_tei	log_tfp	log_tei
log_tfp		-0.030** (0.014)		-0.023* (0.012)		-0.023** (0.011)		-0.022** (0.011)
log_tei	7.859 (5.597)		7.579 (5.558)		2.928 (7.072)		2.746 (8.355)	
log_va	0.269*** (0.030)	0.003 (0.003)	0.268*** (0.029)	0.001 (0.002)	0.346*** (0.046)	0.002 (0.003)	0.353*** (0.052)	0.002 (0.003)
intk	-0.069 (0.051)	0.002 (0.002)	-0.076 (0.053)	0.002 (0.002)	0.204*** (0.055)	0.001 (0.003)	0.233*** (0.057)	0.001 (0.004)
sizze	-0.259*** (0.066)		-0.453*** (0.134)					
lossper_due_out		0.0004*** (0.0001)		0.0004*** (0.0001)		0.0003*** (0.0001)		0.0003** (0.0001)
cur			-0.002 (0.003)				0.001 (0.0015)	
size*cur			0.003 (0.002)					
skill					-0.001*** (0.0003)		-0.001 (0.0004)	
skill*cur							-0.000 (0.000)	
Constant	-2.914*** (0.443)	-0.012 (0.0368)	-2.726*** (0.571)	0.005 (0.0313)	-4.256*** (0.740)	0.002 (0.0425)	-4.432*** (0.899)	0.003 (0.043)
Observations	1,127	1,127	1,099	1,099	886	886	868	868
R-squared	0.881	0.004	0.884	0.088	0.929	0.125	0.930	0.140

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 ; all models include dummy country*time, industry*time and country*industry variables.

7 Robustness

The obstacle perceived as such by the firms' managers is considered above to take into account the firm's accessibility to the financial market and reliable electricity. As these variables are binary, the value of 1 has the same weight for all countries. But this assumption loses its relevance once we account for the fact that countries do not have the same development level. For example, an Egyptian firm and a Togolese firm that claim that electricity (or finance) is a major obstacle are unlikely to face the same situation. The Egyptian firm may face, on average, three outages per week, while the Togolese firm faces, on average, ten outages per week with different impacts on productivity and energy intensity. In this case, it could be easier for the Egyptian firm to overcome its obstacle compared to the Togolese firm. If the sample is dominated by Egyptian firms, this could lead to the results found previously. Hence, it is important to take into account the global situation of the country in which each firm operates. To do so, for each firm, we interact

the variable of electricity obstacle and the rate of electricity access at the country level, on the one side, and on the other side, the variable of financial obstacle and the financial development indicator of its country. We measure financial development with banks' credit to the private sector in the percentage of GDP and the financial development index developed by [Svirydzenka, 2016]. The benchmark results (Tables 4.1, 4.2, 4.3) suggest that the firms facing obstacles are susceptible to improving their performance. If this result remains the same for the interaction term, that means firms improve their performance when they operate in an environment where the financial sector or electrical infrastructures are developed. Furthermore, there is another way to interpret the interaction term. Given that the value 0 means "no obstacle or minor obstacle", higher values of the interaction variable could also mean higher levels of obstacle. However, this reasoning runs against the previous one and could generate some confusion. To clarify this, we have taken the complementary values, that is, 100 minus the values of the electricity access rate, and 1 minus the values of the financial development indicator. As values of the share of private bank credit to GDP are greater than 100%, we normalize²³ this indicator so that its values range between 0 and 1. If the sample is dominated by firms that are in countries less financially and infrastructurally vulnerable, they could lead to the estimated parameters of the benchmark results. By taking into account the development level of countries, we hope that if a firm that faces any obstacle is located in a low-income country, it would not be able to improve for example its productivity and the coefficient could become negative or at least lose its significance. We have re-estimated the model specifications of the impact of China's penetration on firms' productivity and (total) energy intensity, and conditioned on firms' size. The findings are reported in appendix 2-7. The first column considers the financial obstacle variable ($finan_obst*(1 - bank_credit)$), while the second considers the electricity obstacle variable ($elect_obst*(1 - elect_rate)$). The third column includes both obstacles while the fourth adds their interaction. The last three columns re-estimate the previous model specifications by considering the second variable of financial obstacle ($finan_obst*(1 - FD)$).

In Appendices 2 and 5, the coefficients of the variables that represent china's penetration, and other trading partners' penetration, as well as those of other control variables have maintained their signs and their statistical significance compared to the benchmark results (Table 4.1). The estimation results reported in Appendix 2 suggest that the new variables of finance and electricity obstacles have maintained their sign and statistical significance when they are introduced separately in the model. But, when they are introduced together in the same specification, they are no longer statistically significant. Conversely, the results related to firms' size align broadly with those in Appendix 5 and the benchmark results. However, the electricity obstacle shows a positive effect on productivity for some specifications of SMEs, but significant only at the 10% level. This effect is difficult to explain. The interaction term of both obstacle variables is not statistically significant for SMEs, but it is slightly significant for other firms. Hence, we retain

23.

$$bank_credit = \frac{privcrebybandeptogdp - \min(privcrebybandeptogdp)}{\max(privcrebybandeptogdp) - \min(privcrebybandeptogdp)}$$

where $bank_credit$ is the normalized value and $privcrebybandeptogdp$ is the observed value; min and max mean the minimum and the maximum, respectively

from these results that the competition from China leads SMEs to invest when they are confronted with electricity obstacles, but not financial obstacles. Inversely, large firms invest only when they are confronted with financial obstacles in the context of competitive pressure from China.

Appendices 3 and 6 display estimation results about electricity intensity in the full sample and by subsample according to firms' size, respectively, while Appendices 4 and 7 present (in the same order as previously) the estimation results about the total energy intensity, which takes into account the fuel cost to generate electricity. In the first case, the findings align with those found in Table 4.2. We find that, in almost all cases, neither the variable of finance obstacle nor that of electricity obstacles have a statistically significant impact as Chinese import competition in the market increases. But the latter tends to reduce the electricity intensity in the last three columns that consider FDI as a financial obstacle, mainly for SMEs. The electricity intensity of large firms seems to be insensitive to china's penetration (Appendix 6). These results are confirmed by those reported in Appendix 7, where only the total energy intensity of SMEs is negatively and significantly affected by Chinese import competition. Likewise, we can also learn from Appendix 7 that the competition from China leads to an increase in SMEs' energy intensity when they are confronted with financial obstacles maybe because they invest in new generators in the context of increased competition in the market.

Finally, we do not have enough arguments to argue that there is a difference in the magnitude of obstacles faced by African firms conditioned on their country's level of development, or that the effect of china's penetration on firms' performance varies according to the development level of the country in which the firm operates. Overall, SMEs that face electricity obstacles make investments to fix the electricity problem while large African firms facing financial obstacles tend to invest when competition from China intensifies in the domestic market.

8 Conclusions

China's emergence in the international market has attracted increased attention in the economic literature. Many papers have analyzed its impacts on developed or developing countries. This literature also suggests, for example, that trade with foreign countries leads to changes in firms' behavior. Few papers have analyzed in depth the effects of China's competitive pressure on firms' characteristics in African markets. This paper contributes to filling partly this gap in the literature by analyzing the incentive effect of Sino-African trade on African firms' productivity and energy efficiency. Based on various data and empirical strategies, the results suggest that China's penetration into African markets has induced, on average, a productivity loss and a reduction in energy intensity among African SMEs while we find no statistically significant impact on the performance of large firms. But drawing from our theoretical model, we have deduced that a reduction in energy intensity cannot be attributed to improved energy efficiency but rather to a significant decrease in firms' production. Likewise, improving the firm productivity leads to a drop in its energy intensity but there is no evidence of reverse causality. As a result, the more companies lose in technical efficiency (TFP) following Chinese penetration, the more they lose in energy efficiency.

We also investigate whether the finance and electricity obstacles are potential factors that can explain these results. These are, in fact, the main threats to firms in less developed countries, mainly African ones. The empirical results show that both obstacles are barriers to improving firms' performance for SMEs. But as china's penetration in the market increases, SMEs that are confronted with an electricity obstacle improve their productivity but experience an increase in their energy intensity when they face financial obstacles. This result is ambiguous and can be explained in two ways. On the other hand, china's penetration pressure compels SMEs to overcome their financial barriers and invest in electrical generators so as to continuously produce in the market. This leads to their productivity growth with in return a high expense in the purchase of diesel. On the other hand, we can also interpret this result by the fact that financial obstacles represent a barrier for SMEs to invest in energy efficiency further to china's penetration. As a consequence, their use of energy increases. But the first explanation is more consistent. As for the large African firms, their performance is not affected by electricity or financial obstacles. However, as China's penetration grows, large African firms that face financial obstacles tend to improve their productivity, but china's penetration does not necessarily affect their energy intensity.

Finally, we retain from the results that China's competitive pressure required not only an improvement in African firms' traditional performance but also their efficiency, including through innovation at the product level. These results are consistent with previous literature. However, we also find that the improvement in productivity and energy efficiency has not been large enough to sustain foreign competition mainly from China, which competes on price and quality.

However, the penetration of Chinese products into African markets can lead struggling domestic firms to find a way to improve their performance, otherwise, they would lose part of their market share, and in the extreme case, be constrained to leave the market.

Based on these results, African firms should hire highly skilled workers and invest in research and development in order to innovate at both the technology and products level. African governments should pay particular attention to the educational sector to make available to companies a well-trained workforce. In addition, governments should endeavor to supply electricity of good quality to SMEs and facilitate their access to the financial market. The lack of reliable electricity leads firms to use electrical generators that are not only expensive but also pollute enormously since they are powered by fossil fuel.

An avenue for future research could be to investigate the effect of China's input penetration in African markets on African firms' performance. However, this exercise requires information about the origins of inputs used by these firms in order to take into account the share of China's inputs. So more detailed firm-level data is required.

9 Appendixes

Appendix 1 : Variables description

Variable	Name	obs	mean	stddev	min	max
China's penetration	china_pen	4871	20.445	42.811	.009	384.815
Instrument	autor_pen	4947	48.978	54.784	.842	268.331
India's penetration	india_pen	4700	6.249	10.894	.005	80.466
FTA's members' penetration	fta_pen	4787	17.321	102.883	.005	6554.823
Exporting firms	exporter	5395	.237	.425	0	1
Firms' size	size	5358	.256	.437	0	1
Full time employees	ful_time_employee	5357	118.699	949.099	1	64000
Percentage of output lost	lossper_due_out	3107	11.019	15.204	0	100
Logarithm of capital cost	log_kcost	3093	11.758	3.425	.006	26.643
Logarithm of labor cost	log_lacost	4431	10.831	2.853	2.137	23.318
Logarithm of value added	log_va	3587	12.615	3.0769	3.053	25.341
Logarithm of intermediate input cost	log_iinput	3709	11.465	3.408	.624	26.617
Logarithm of sale	log_sale	4590	12.912	3.097	3.148	26.840
Logarithm of electricity cost	log_elcost	4753	12.459	3.088	0	23.719
Logarithm of fuel cost	log_fuel	2411	9.293	3.031	.226	23.160
Capacity utilization rate	cur	4216	69.202	22.953	1	100
Dummy of electricity obstacle	elect_obst	4422	.593	.491	0	1
Dummy of finance obstacle	finan_obst	4090	.502	.500	0	1
Logarithm of productivity	log_tfp	1793	2.680	2.432	0.000	10.668
Logarithm of electricity intensity	log_ei	4494	.034	.056	0.000	.626
Logarithm of total energy intensity	log_tei	4524	.038	.062	0.000	.719
Fuel percent spent on generator	percent_generator	2079	29.559	28.739	0.5	100
Firms has or not a generator	generator	5395	.385	.487	0	1
Financial development index	FD	4901	.160	.070	.055	.343
Private credit by bank to GDP	privcrebybandeptogdp	4859	25.686	38.458	3.012	378.531
Private credit by bank to GDP (normalized)	bank_credit	4859	.060	.102	0	1
Capital intensity	intk	3,087	.714	.741	.0002	8.304

Notes : *size* is sometimes used instead of *size*. The latter contains two modalities and the former, three.

Appendix 2 : China's penetration and firms' productivity

VARIABLES	log_tfp	log_tfp	log_tfp	log_tfp	log_tfp	log_tfp	log_tfp
china_pen1	-0.014** (0.006)	-0.010* (0.006)	-0.011** (0.005)	-0.011** (0.005)	-0.014** (0.006)	-0.011** (0.005)	-0.011** (0.005)
india_pen1	-0.0002 (0.009)	0.008 (0.009)	0.003 (0.011)	0.003 (0.011)	0.001 (0.010)	0.003 (0.011)	0.003 (0.011)
fta_pen1	-0.006 (0.004)	-0.006* (0.003)	-0.006 (0.004)	-0.006 (0.004)	-0.006 (0.004)	-0.006 (0.004)	-0.006 (0.004)
exporter	0.235*** (0.084)	0.227*** (0.075)	0.247*** (0.092)	0.247*** (0.092)	0.257*** (0.084)	0.271*** (0.091)	0.271*** (0.091)
size	0.363*** (0.078)	0.320*** (0.068)	0.371*** (0.084)	0.373*** (0.084)	0.373*** (0.077)	0.380*** (0.084)	0.382*** (0.084)
finan_obst*(1 - bank_credit)	-0.147* (0.079)		-0.063 (0.072)	-0.085 (0.073)			
finan_obst*(1 - bank_credit)*china_pen1	0.009* (0.004)						
elect_obst*(1 - elect_rate)		-0.000 (0.002)	0.002 (0.002)	0.001 (0.002)		0.002 (0.001)	0.001 (0.002)
elect_obst*(1 - elect_rate)*china_pen1		0.0002** (0.000)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				0.000 (0.000)			
finan_obst*(1 - FD)					-0.181** (0.085)	-0.094 (0.079)	-0.118 (0.080)
finan_obst*(1 - FD)*china_pen1					0.009* (0.005)		
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.000 (0.0001)
Constant	0.113** (0.057)	0.008 (0.084)	-0.026 (0.097)	0.011 (0.106)	0.123** (0.055)	-0.011 (0.090)	0.023 (0.098)
Observations	1,165	1,389	993	993	1,182	1,011	1,011
R-squared	0.846	0.858	0.854	0.854	0.840	0.849	0.849
IV F-stat	113.3	161.2	144.4	140.5	107.5	145	139

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 ; all models include dummy country*time, industry*time and country*industry variables.

Appendix 3 : China's penetration and firms' electricity intensity

VARIABLES	log_ei	log_ei	log_ei	log_ei	log_ei	log_ei	log_ei
china_pen1	-0.001*	-0.001*	-0.001*	-0.001*	-0.002	-0.001*	-0.001**
	(0.0003)	(0.0006)	(0.0003)	(0.0003)	(0.0014)	(0.0003)	(0.0004)
india_pen1	0.001**	0.0003	0.001***	0.001***	0.001*	0.0003	0.001***
	(0.0004)	(0.0002)	(0.0005)	(0.0005)	(0.0008)	(0.0003)	(0.0003)
fta_pen1	-0.0001	0.000	-0.0002	-0.0002	-0.0004	-0.0004	-0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
exporter	-0.001	-0.005	-0.004	-0.004	0.0005	-0.003	-0.004
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
size	-0.007**	-0.008***	-0.009***	-0.009***	-0.012*	-0.014***	-0.0125***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.004)	(0.004)
finan_obst*(1 - bank_credit)	0.001		0.002	0.002			
	(0.003)		(0.003)	(0.003)			
finan_obst*(1 - bank_credit)*china_pen1	0.0003**						
	(0.0001)						
elect_obst*(1 - elect_rate)		-0.0002	0.000	0.000		0.000	-0.000
		(0.0001)	(0.000)	(0.000)		(0.000)	(0.000)
elect_obst*(1 - elect_rate)*china_pen1		0.000*					
		(0.000)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				0.000			
				(0.000)			
finan_obst*(1 - FD)					-0.035	0.007*	-0.005
					(0.028)	(0.004)	(0.005)
finan_obst*(1 - FD)*china_pen1					0.002		
					(0.0014)		
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.000**
							(0.000)
lossper_due_out	0.0003**	0.0003***	0.0003***	0.0003***	0.0004**	0.0003**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Constant	0.018***	0.023**	0.011***	0.011***	0.042**	0.004	0.020***
	(0.006)	(0.009)	(0.004)	(0.005)	(0.019)	(0.006)	(0.006)
Observations	1,564	1,898	1,282	1,282	1,512	1,237	1,237
R-squared	0.254	0.154	0.217	0.216			0.139
IV F-stat	108.9	33.71	96.10	92.64	6.195	7.571	25.44

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

Appendix 4 : China's penetration and firms' total energy intensity

VARIABLES	log_te1	log_te1	log_te1	log_te1	log_te1	log_te1	log_te1
china_pen1	-0.001** (0.0005)	-0.002** (0.0008)	-0.001** (0.0005)	-0.001** (0.0005)	-0.002* (0.001)	-0.001** (0.0005)	-0.001** (0.001)
india_pen1	0.001** (0.0004)	0.0002 (0.0003)	0.001* (0.0005)	0.001* (0.0005)	0.002* (0.0008)	0.0001 (0.0005)	0.001*** (0.0003)
fta_pen1	-0.0003 (0.0002)	-0.0003 (0.0002)	-0.0003 (0.0002)	-0.0003 (0.0002)	-0.001** (0.0003)	-0.001*** (0.0004)	-0.001** (0.0003)
exporter	0.002 (0.004)	-0.003 (0.004)	-0.0003 (0.005)	-0.0002 (0.005)	0.005 (0.006)	0.002 (0.005)	0.001 (0.005)
size	-0.008** (0.003)	-0.009*** (0.004)	-0.011*** (0.004)	-0.011*** (0.004)	-0.012** (0.006)	-0.018*** (0.006)	-0.016*** (0.005)
lossper_due_out	0.0003** (0.0001)	0.0002** (0.0001)	0.0003** (0.0001)	0.0003** (0.0001)	0.0005** (0.0002)	0.0003** (0.0001)	0.0003* (0.0001)
finan_obst*(1 - bank_credit)	-0.003 (0.004)		0.001 (0.004)	0.001 (0.004)			
finan_obst*(1 - bank_credit)*china_pen1	0.0005** (0.0002)						
elect_obst*(1 - elect_rate)		-0.0003 (0.0002)	0.0001 (0.0001)	0.000 (0.0001)		0.0002 (0.0001)	-0.0001 (0.0001)
elect_obst*(1 - elect_rate)*china_pen1		0.0001** (0.0001)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				0.000 (0.000)			
finan_obst*(1 - FD)					-0.038 (0.023)	0.010* (0.006)	-0.011 (0.007)
finan_obst*(1 - FD)*china_pen1					0.002* (0.001)		
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.00002** (0.000)
Constant	0.029*** (0.007)	0.034*** (0.012)	0.019*** (0.006)	0.021*** (0.006)	0.051*** (0.017)	0.008 (0.009)	0.034*** (0.009)
Observations	1,575	1,910	1,292	1,292	1,524	1,249	1,249
R-squared	0.261	0.098	0.234	0.231			0.090
IV F-stat	94.83	33.21	83.53	80.20	7.539	7.117	24.15

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

Appendix 5 : China's penetration and firms' productivity by firms' size

VARIABLES		log_tfp	log_tfp	log_tfp	log_tfp	log_tfp	log_tfp	log_tfp	
Small	china_pen1	-0.018** (0.008)	-0.013* (0.007)	-0.013** (0.006)	-0.013** (0.006)	-0.017** (0.008)	-0.012** (0.006)	-0.012* (0.006)	
	finan_obst*(1 - bank_credit)	-0.201** (0.0923)		-0.125 (0.085)	-0.126 (0.087)				
	finan_obst*(1 - bank_credit)*china_pen1	0.009 (0.006)							
	elect_obst*(1 - elect_rate)		0.0001 (0.002)	0.003* (0.002)	0.003* (0.002)		0.003* (0.002)	0.003* (0.002)	
	elect_obst*(1 - elect_rate)*china_pen1		0.0002** (0.0001)						
	finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				0.0005 (0.0001)				
	finan_obst*(1 - FD)					-0.215** (0.096)	-0.154* (0.093)	-0.151 (0.094)	
	finan_obst*(1 - FD)*china_pen1					0.009 (0.006)			
	finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							-0.000 (0.0001)	
	Constant	0.152** (0.067)	0.001 (0.087)	-0.055 (0.101)	-0.053 (0.112)	0.146** (0.063)	-0.036 (0.094)	-0.039 (0.104)	
	Observations	838	993	710	710	849	721	721	
	R-squared	0.853	0.876	0.865	0.865	0.849	0.862	0.862	
	Large	china_pen1	-0.0160* (0.009)	-0.0061 (0.009)	-0.0103 (0.009)	-0.0120 (0.008)	-0.0185* (0.009)	-0.0116 (0.009)	-0.0129 (0.009)
		finan_obst*(1 - bank_credit)	-0.129 (0.154)		0.086 (0.130)	-0.057 (0.125)			
finan_obst*(1 - bank_credit)*china_pen1		0.0225** (0.00986)							
elect_obst*(1 - elect_rate)			-0.0006 (0.004)	-0.005 (0.006)	-0.007 (0.006)		-0.002 (0.004)	-0.004 (0.005)	
elect_obst*(1 - elect_rate)*china_pen1			0.0002 (0.0001)						
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1					0.001 (0.001)				
finan_obst*(1 - FD)						-0.185 (0.174)	0.0842 (0.151)	-0.105 (0.150)	
finan_obst*(1 - FD)*china_pen1						0.031** (0.0130)			
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1								0.002* (0.001)	
Constant		4.395*** (0.650)	3.022*** (0.581)	4.665*** (0.558)	4.910*** (0.569)	3.234*** (1.165)	3.119** (1.455)	2.393* (1.319)	
Observations		327	396	283	283	333	290	290	
R-squared		0.852	0.832	0.855	0.857	0.842	0.846	0.850	

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 ; all models include dummy country*time, industry*time and country*industry variables.

Appendix 6 : China's penetration and firms' electricity intensity by firms' size

VARIABLES		log_ei	log_ei	log_ei	log_ei	log_ei	log_ei	log_ei
Small	china_pen1	-0.0006*	-0.0001	-0.0005	-0.0005	-0.0012**	-0.0005**	-0.0006**
		(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0002)	(0.0003)
	finan_obst*(1 - bank_credit)	0.002		0.004	0.004			
		(0.004)		(0.003)	(0.003)			
	finan_obst*(1 - bank_credit)*china_pen1	0.0003*						
		(0.0001)						
	elect_obst*(1 - elect_rate)		0.000	0.000	0.000		0.000	0.000
			(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
	elect_obst*(1 - elect_rate)*china_pen1		-0.000					
			(0.000)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				-0.000				
				(0.000)				
finan_obst*(1 - FD)					-0.004	0.007*	0.005	
					(0.006)	(0.004)	(0.004)	
finan_obst*(1 - FD)*china_pen1					0.0005*			
					(0.0003)			
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.000	
							(0.000)	
Constant	0.0162***	0.006	0.008*	0.008*	0.020***	0.006	0.008*	
	(0.006)	(0.005)	(0.004)	(0.004)	(0.007)	(0.004)	(0.004)	
Observations	1,169	1,398	957	957	1,114	912	912	
R-squared	0.346	0.354	0.310	0.310	0.249	0.314	0.310	
Large	china_pen1	-0.0002	-0.005	-0.0005	-0.0005	-0.059	-0.009	-0.001
		(0.001)	(0.006)	(0.001)	(0.001)	(3.732)	(0.099)	(0.002)
	finan_obst*(1 - bank_credit)	0.001		-0.006	-0.009			
		(0.007)		(0.007)	(0.008)			
	finan_obst*(1 - bank_credit)*china_pen1	-0.0001						
		(0.0004)						
	elect_obst*(1 - elect_rate)		-0.0008	0.0002**	0.0001		0.001	0.000
			(0.001)	(.0001)	(.0001)		(0.008)	(.0001)
	elect_obst*(1 - elect_rate)*china_pen1		.000					
			(0.000)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				.000				
				(0.000)				
finan_obst*(1 - FD)					-0.630	-0.011	-0.013	
					(39.88)	(0.056)	(0.015)	
finan_obst*(1 - FD)*china_pen1					0.023			
					(1.430)			
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.000	
							(0.000)	
Constant	0.060***	0.083	0.013	0.039	0.750	0.073	0.052	
	(0.017)	(0.077)	(0.025)	(0.032)	(43.59)	(0.423)	(0.042)	
Observations	395	500	325	325	398	325	325	
R-squared	0.150		0.195	0.198			0.055	
Robust standard errors in parentheses								

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

Appendix 7 : China's penetration and firms' total energy intensity by firms' size

VARIABLES		log_te1	log_te1	log_te1	log_te1	log_te1	log_te1	log_te1
Small	china_pen1	-0.001**	-0.001	-0.001**	-0.001**	-0.001***	-0.001***	-0.001***
		(0.001)	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0004)	(0.0005)
	finan_obst*(1 - bank_credit)	-0.001		0.005	0.004			
		(0.005)		(0.005)	(0.005)			
	finan_obst*(1 - bank_credit)*china_pen1	0.0005*						
		(0.0002)						
	elect_obst*(1 - elect_rate)		0.0001	0.0003	0.0002		0.0004	0.0004
			(0.0008)	(0.0006)	(0.0007)		(0.0007)	(0.0007)
	elect_obst*(1 - elect_rate)*china_pen1		0.000					
			(0.000)					
finan_obst*(1 - FD)					-0.008	0.009*	0.004	
					(0.007)	(0.005)	(0.005)	
finan_obst*(1 - FD)*china_pen1					0.0007**			
					(0.0003)			
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.000*	
							(0.000)	
Constant	0.027***	0.017**	0.018***	0.018***	0.030***	0.013**	0.019***	
	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	
Observations	1,176	1,405	964	964	1,120	919	919	
R-squared	0.331	0.353	0.322	0.322	0.266	0.303	0.289	
Large	china_pen1	-0.0002	-0.006	-0.0004	-0.0005	0.033	-0.012	-0.001
		(0.001)	(0.006)	(0.001)	(0.001)	(1.333)	(0.169)	(0.002)
	finan_obst*(1 - bank_credit)	-0.0002		-0.008	-0.009			
		(0.008)		(0.007)	(0.008)			
	finan_obst*(1 - bank_credit)*china_pen1	-0.0001						
		(0.0004)						
	elect_obst*(1 - elect_rate)		-0.001	0.0004***	0.0004*		0.001	0.0002
			(0.001)	(0.0001)	(0.0002)		(0.012)	(0.0001)
	elect_obst*(1 - elect_rate)*china_pen1		0.0003					
			(0.0003)					
finan_obst*(1 - bank_credit)*elect_obst*(1 - elect_rate)*china_pen1				0.000				
				(0.0002)				
finan_obst*(1 - FD)					0.340	-0.016	-0.017	
					(13.92)	(0.076)	(0.016)	
finan_obst*(1 - FD)*china_pen1					-0.013			
					(0.511)			
finan_obst*(1 - FD)*elect_obst*(1 - elect_rate)*china_pen1							0.0001	
							(0.0001)	
Constant	0.063***	0.075	-0.002	0.007	-0.316	0.080	0.039	
	(0.017)	(0.079)	(0.029)	(0.041)	(15.37)	(0.849)	(0.046)	
Observations	399	505	328	328	404	330	330	
R-squared	0.227		0.297	0.297			0.216	

Notes : Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1; all models include dummy country*time, industry*time and country*industry variables.

Chapitre 5

General Conclusion

According to Regional Economic Outlook (IMF, 2022) and Economic Development in Africa Report (UNCTAD, 2022), most African countries presented a high rate of economic growth before the recent crises, namely the covid-19 pandemic and the war in Ukraine. This economic performance is observed in the environment where trade between Africa and China, which has been the main African trading partner since 2009, has been on the rise. However, the high economic growth did not allow Sub-Saharan African countries to reverse the trend of traditional evils including energy poverty and low financial development, which impeded the real take-off of these economies for sustainable growth and the reduction of households' poverty. The present thesis investigates in its first chapter the effect of access to electricity on Tanzanian households' consumption and how it affects the growth of home-based businesses. The second chapter assesses the effect of China's penetration on the growth of African manufacturing firms in both domestic and foreign markets. The last chapter has explored how Chinese product competition has influenced firms' productivity and energy efficiency. This chapter has distinguished small and medium enterprises from large ones, that faced or not financial and/or electricity constraints.

Based on the data from the first and the last wave of the latest panel survey of Tanzania, the analysis made in the first chapter has generated several results. First, electricity access has led to an increase in household consumption. Second, we have found from the latest wave, that access to electricity has not affected significantly home-based businesses' income. However, access to electricity has affected positively and significantly the stock of physical capital, which has, in turn, led to a strong increase in home-based business income. The results are similar for the workforce of these businesses. Indeed, access to electricity does not exert a significant impact on the probability to have a worker or the number of employees of the home-based business. However, the stock of physical capital leads to a positive and significant impact on these variables. Hence, the extension of the duration of the activity of home-based businesses allowed by the electric lamps is not enough to facilitate their growth.

The panel of African firms from the enterprises' survey data of the World Bank, the international trade data from CEPPII, and the national input-output data from Eora's database are the main datasets used in the second chapter to study how China's penetration into African markets

affects the African firms' growth measured by firms' sales and firms' size. Results have revealed that only small and younger firms are victims of Chinese product competition. The large firms have shown a pro-competitive effect. In the common external markets, Chinese products have crowded out African ones. This negative and significant impact of Chinese products on exporting firms' growth is more pronounced in developed countries markets. Surprisingly, the Chinese input penetration has affected negatively firms' growth. This peculiar result may be attributed to the indicator used to measure Chinese input penetration. The last chapter is as rich in the database as the previous one. To the ESD, BACI, and Eora data, we have added the financial development indicators from the World Bank and International Monetary Fund. Our theoretical model on the relationship between energy intensity (proxy of energy efficiency), productivity, and production of any manufacturing firm, has shown that the energy intensity is inversely related to the firm's productivity, while there is a logarithmic (that is a non-linear) relationship between each of these indicators and the firm's production-level. As the energy intensity is inversely related to energy efficiency, we deduce from these results that the improvement of energy efficiency can lead to higher productivity and vice-versa. We also deduce that the energy intensity and productivity vary slowly for the high production level but more rapidly for the low production level *ceteris paribus*. The empirical results suggest that Chinese product competition in African markets has been associated with a reduction of both energy intensity and productivity for SMEs, while there is no statistically significant impact on large firms' energy intensity and productivity. However, the productivity improvement has led to a reduction in energy intensity but there is no reverse causality. These results seem to be conflicting, but referring to our theoretical model and the second chapter's results, we have deduced that the reduction of (small) firm production level further to China's penetration may lead to the reduction of both productivity and energy intensity. The reduction of the quantity produced has resulted in the reduction of energy consumed, *ceteris paribus*, and consequently the reduction of the ratio of the energy consumed to the quantity produced. Furthermore, the empirical results have revealed that small firms that face the electricity obstacle and the large ones that are confronted with the financial obstacle tend to improve their productivity as Chinese competition increases in the domestic market. At the same time, the energy intensity of the small firms also increases. These firms would invest in electric generators in order to overcome their electricity obstacle and increase their production-level, and ultimately, their productivity. We also deduce that firms that did not face any obstacle have lost in performance. These results highlight the insufficiency of firms' traditional performance in terms of productivity and energy efficiency, to face Chinese product competition. They would also need to improve their innovation performance at the product level by investing in research and development.

Policy implications

Summing up, this thesis provides four important results. First, access to electricity benefits households that are well-equipped in physical capital. Second, small and young firms are the most adversely affected by Chinese product competition. Third, the Chinese competition forces

firms that face market failures to overcome these failures and improve their performance. Finally, firms should find another approach, for instance, increasing innovation at the product level, to face Chinese product competition. These results could be useful for African countries to orient public investments toward achieving sustainable and inclusive economic growth on one hand. On the other hand, they could be useful for African Development Bank (AfDB) to well accomplish its development mission across the continent. Indeed, the AfDB Group ambitions to spur sustainable economic development and social progress in its regional member countries (RMCs), thus contributing to poverty reduction.¹ As poverty reduction, electrification, and industrial development are the first common objectives of these two institutions, it is important to note that before an electrification project brings households out of poverty, it must be accompanied by a micro-financial program to enable the poor households to make investments in their home-based businesses. Likewise, reliable electricity is also critical for African firms, mainly the small ones to reduce their vulnerability to China's competition. Overall, it is important to give priority to the education sector in order to provide a skilled workforce to African firms to generate profitable investments. However, these firms' investments required the existence of a well-developed financial sector to enable both SMEs and large enterprises to access easily financial credits to finance their businesses.

1. <https://www.afdb.org/en/about/mission-strategy>

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RÉSUMÉ

Les pays africains aspirent à un développement industriel pour diversifier leurs exportations, actuellement concentrées en ressources naturelles. Cependant, l'électrification et le renforcement de la compétitivité des entreprises nationales restent un défi lorsqu'elles font face à la concurrence des importations, notamment celle chinoise. Ce sujet est au cœur de la présente thèse, divisée en trois chapitres. Le premier analyse l'impact de l'accès des ménages tanzaniens à l'électricité sur leur consommation et leurs revenus issus des activités domestiques. Les résultats suggèrent que l'accès à l'électricité entraîne une augmentation de la consommation quotidienne des ménages. De même, le chiffre d'affaires et le nombre d'emplois créés sont plus élevés dans les activités à forte intensité capitalistique favorisées par l'électricité. Dans le deuxième chapitre consacré à l'effet du commerce sino-africain sur la croissance des entreprises africaines, les résultats empiriques (RE) suggèrent que la pénétration de la Chine (PC) réduit la croissance des petites et jeunes entreprises, tandis que les grosses entreprises ont connu un effet pro-concurrentiel. Les entreprises exportatrices ont été doublement affectées, car leur croissance a baissé lorsque la PC a augmenté sur le marché extérieur commun. Enfin, le troisième chapitre a étudié comment la PC sur les marchés africains a affecté la performance des entreprises (PE). D'un point de vue théorique, la productivité (PTF) et l'intensité énergétique (IE) des entreprises sont inversement liées, tandis qu'il existe une relation logarithmique entre ces indicateurs et le niveau de production des entreprises. Les RE montrent que la PC sur le marché africain a entraîné une baisse de la PTF et de l'IE des petites et moyennes entreprises sans impact significatif sur les grosses entreprises. Sur la base des résultats théoriques, nous déduisons que la diminution de l'IE pourrait s'expliquer par la réduction du niveau de production. Alors que les obstacles électriques et financiers affectent négativement la PE, les petites entreprises confrontées aux obstacles électriques et les grandes entreprises confrontées aux obstacles financiers ont amélioré leurs performances sous l'impulsion de la compétition chinoise. Les RE ont également révélé que la PTF affecte négativement l'IE, sans qu'il y ait de causalité inverse.

MOTS CLÉS

Energie, ménage, consommation, commerce Chine-Afrique, Entreprise, Productivité, Développement financier

ABSTRACT

African countries aspire to industrial development to diversify their exports, currently concentrated on natural resources. However, the electrification and the reinforcement of the competitiveness of national companies remain a challenge when companies face fierce import competition, including from Chinese products. This topic is at the heart of the present thesis, which is divided into three chapters. The first chapter analyses the impact of Tanzanian households' access to electricity on their consumption and income from home-based activities. The findings suggest that electricity access leads to an increase in households' day-to-day consumption. Likewise, turnover and the number of jobs created have resulted in capital-intensive businesses, but electricity is essential to be capital-intensive. In the second chapter dedicated to the effect of Sino-African trade on African firms' growth, the empirical evidence suggests that China's penetration reduces the growth of small and younger firms, while larger firms have experienced a pro-competitive effect. Exporting firms were hit twice, as their growth decreased when China's penetration increased in the common external market. Finally, the third chapter investigates how China's penetration into African markets has affected firms' performance. From the theoretical perspective, firms' productivity and energy intensity are inversely related, while there is a logarithmic relationship between these indicators and firm production level. Empirical results show that China's penetration into the African market has led to a decrease in both productivity and energy intensity of small and medium firms, but has exerted no significant impact on large firms. Based on the theoretical results, we deduce that the decrease in energy intensity could be explained by the reduction of the production level. While both electricity and financial obstacles affect negatively firms' performance, small firms facing electricity barriers and large firms facing financial barriers have improved their performance under the impulse of the Chinese competition. Empirical results have also revealed that productivity negatively affects energy intensity, while there is no reverse causality.

KEYWORDS

Energy, Household, Consumption, China-African trade, Firm, Productivity, Financial development