ANNALS OF ECONOMICS AND FINANCE **17-2**, 403–431 (2016)

The Impact of Africa-China Trade Openness on Technology Transfer and Economic Growth for Africa: A Dynamic Panel Data Approach

Dinkneh Gebre Borojo*

School of Economics and Management, Southwest Jiaotong University, Chengdu, China
E-mail: g10dinkneh@yahoo.com

and

Yushi Jiang

School of Economics and Management, Southwest Jiaotong University, Chengdu, China
E-mail: 906375866@qq.com

Using two-step system GMM estimator we analyze the impact of Africa-China trade openness on TFP and economic growth for 38 African countries for the periods 1995-2013 after controlling for edogeneity. The findings of this study reveal that Africa-China trade openness has robust positive effect on GDP growth of African countries. When Africa-China trade openness is interacted with the institutional quality and human capital of Africa, its effect on TFP is positive and significant. Hence, it needs strong domestic absorptive capacity of Africa to reap technology improvement effect of trade with China. These findings, therefore, provide evidence that Africa-China trade openness is an important contributor of economic growth for Africa.

Key Words: Trade Openness; Technology Transfer; Economic Growth; Africa-China; system GMM.
JEL Classification Numbers: F14, F15.

* Corresponding author. Dinkneh Gebre Borojo acknowledges that this research is supported by National Natural Science Foundation of China (71572156).

1529-7373/2016

1. INTRODUCTION

In recent economic literatures international trade is regarded as one of the major determinants of economic growth. Some literatures such as Andersen and Babula (2008), Sun and Heshmati (2010), Busse and Koniger (2012) disclose that international trade has significant positive impact on economic growth in different countries. Trade and trade policies found to have robust positive effect on economic growth both in short-run and long-run for sub-Saharan African countries (Brückner & Lederman 2012). It can also affect economic growth indirectly by promoting transfer of technology from technology innovative developed economy to less technology innovative developing countries. Therefore, it can be considered as one of the channels to transfer technology from developed economy to less developed economies (Blomstrom, 1986 and Busse & Koniger, 2012). More specifically, trade in capital goods and technological inputs can directly improve productivity of hosting countries by being integrated into production processes and import of services as well. Some studies such as Lucas (1988) and Le (2007) have attempted to assess the importance of imports and exports in transmitting foreign technology to domestic industries and in the process spurring productivity growth. These studies found trade to be a significant channel of technology spillovers and thus an important factor in explaining improvement in total factor productivity. Furthermore, Technology transfer and international trade takes on even greater importance for productivity growth in developing countries as they undertake minimal domestic research and development (Henry, Kneller & Milner, 2003).

According to some historical evidence the economic relationship between China and Africa goes as far back to 500 years (Mohan & Kale, 2007). However, the economic integration between Africa and China is intensified in the last two decades. This integration has been facilitated by bidirectional trade between China and Africa. China total trade with Africa has reached more than 209 billion US dollar in 2013 from barely less than 4 billion US dollar in 1995 (Tralac, 2014). As a result, China is considered as an alternative source of trade partner to Africa resulting with shift of trade relation from Africa's traditional trade and development partners (United States of America and European Union) (Renard, 2011). Therefore, fast growing trade openness of Africa and China is our central point to be analyzed. A few studies have been conducted on the impact of trade openness between China and Africa on economic growth of African countries and technology transfer to them. Some researchers, however, found mixed results on the effects of the trade interaction of these countries on productivity improvement and economic growth of Africa. According to the studies of some researchers trade openness between China and Africa has positive impact on economic growth of African countries. He (2013) us-

ing manufactured exports of Sub-Saharan Africa as a proxy of production of countries found that trade relation with China has positive significant effect on economic development of the countries. However, for others it has insignificant and/or negative impact on total factor productivity and economic growth for African countries. For example, Busse, Erdogan and Mühlen (2014) have revealed that Chinese trade has minimal role on economic growth of African countries. The study conducted by Looy and Haan (2006) found trade relationship between Africa and China become more dominated by China's economic interests. This finding is also supported by Adisu, Sharkey and Okoroafo (2010) concluding Chinese economic integration with Africa has been motivated by a desire to access critical resources. The findings of Elu and Price (2010) show there is no relationship between Africa-China trades with productivity improvement of firms in Africa. Increasing trade openness with China has negative significant effect on the growth rate of total factor productivity for African countries. These studies have attempted to analyze the effect of trade openness alone without considering conditional effect of it on technology transfer and economic growth because trade interaction between them is complex in nature (Uchehara, 2009). For instance, different literatures came to consensus that countries with good institutional quality and human capital better utilize benefit of trade to foster economic growth. So, high level of trade integration and good institutional quality go together and trade openness and education human capital can also be complementary (Chang, Kaltani & Loayza, 2009). Therefore, analyzing the dynamic effect of trade openness between African countries and China on technology improvement and economic growth of African countries is worthwhile.

Hence, this paper aims to analyze the impact of Africa-China trade openness on economic growth and TFP of African countries using two-step system GMM model. More specifically, the objective of this paper is to analyze the impact of trade openness between China and Africa on productivity enhancing technology transfer to Africa and economic growth of African countries and to examine the joint effect of Africa-China trade openness and domestic absorptive capacity of African countries in terms of their institutional quality and human capital on factor productivity improvement and economic growth for Africa.

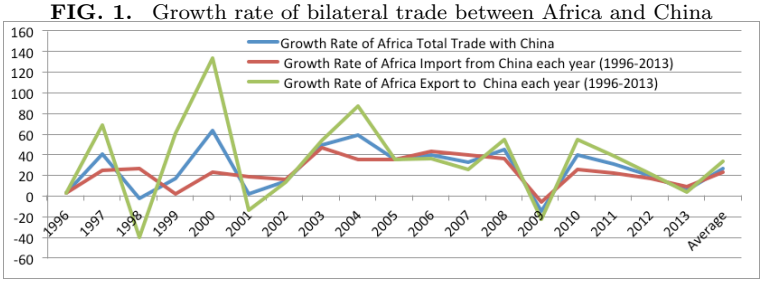
The rest part of this paper is organized as follows: Part two discusses stylized facts on China-Africa economic integration and an overview of economic performance of Africa, Part three presents literature review, part four explains methodology of the study and data, part five presents results and findings of the study and part six contains conclusions and forwards recommendation based on the findings.

2. STYLIZED FACTS ON CHINA-AFRICA ECONOMIC INTEGRATION

2.1. Africa-China bilateral trade

Trade between China and Africa has been increased at the fastest rate since 2000. According to the Figure 1 below, total trade has registered compound growth rate of 24.7% in last twenty years from 1995 to 2013. It also shows that the trade in goods and services has been grown at 26.7% on average for the past two decades. When we spilt it in into import and export components, Chinese commodity export to Africa was grown by 22.7% on average in 2013 from 1995. It was increased to 92.68 billion US Dollar in 2013 merely from 2.49 billion US Dollar in 1995. In addition, China import from Africa is increased by 33.88% in the last two decades. This shows that significant trade interaction has been taken place between Africa and China since 1995.

FIG. 1. Growth rate of bilateral trade between Africa and China



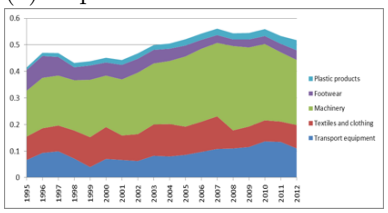
Source: Authors, based on data from Global Trade Atlas

The major commodities imported from China to Africa for last two decades are machineries, textiles and clothing, transport equipment, footwear and plastic products. Among them machinery import was first in share. It was grown by 24% average from 1995 to 2013 (Figure 2). Machinery and equipment relating to foreign research and development are among the channels to generate more technology transfer than others (Isaksson, 2007). Textile and clothing, transport equipment, footwear and plastic products import from China to Africa was also increased by 10%, 8%, 5% and 2%, respectively in the periods 1995-2013 (Tralac, 2014).

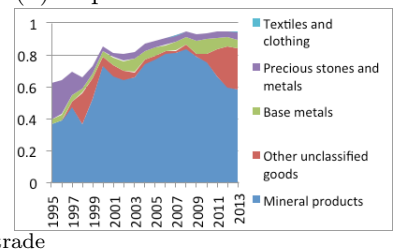
The major destinations of this Chinese export in Africa are South Africa, Nigeria, Egypt, Algeria and Morocco. Almost 52% of total import from China to Africa goes to these countries (Figure 3). Export of Africa relies on minerals and natural resources, primary products and raw-materials and semi-processed products. More than 58% of total export of Africa to China is mineral products such as crude oil, natural gas and copper. The major exporting African countries to China are Angola, South Africa, Sudan, Congo and Equatorial Guinea. They took 76% average share of

FIG. 2. Composition of import and export commodities of Africa from/to China

(a) Import of Africa from China



(b) Export of Africa to China



Source: tralac trade law center Africa-China trade

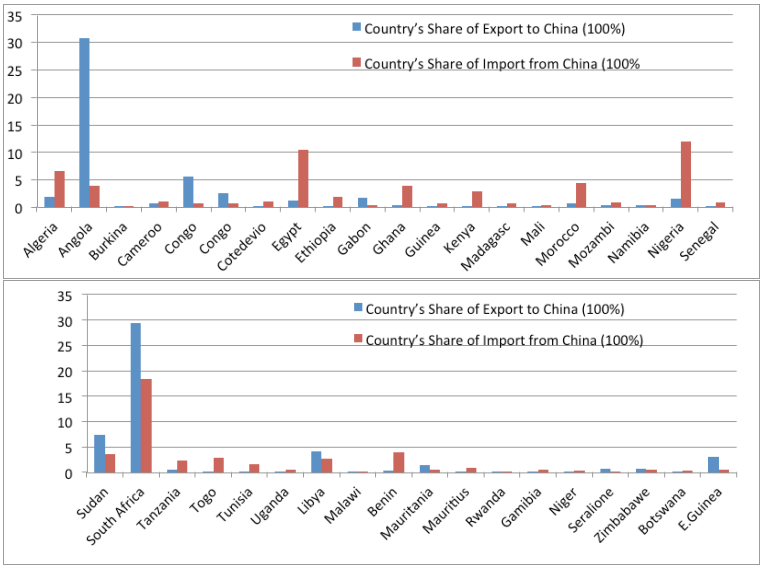
export of Africa to China from 1995 to 2013 (Figure 3). Their export is concentrated on crude oil and other mineral resources and raw materials. For example, 99.5% of Angola export to China is crude oil followed by diamond, granite, cooper and wood (Tralac, 2014). Congo export is also concentrated on crude oil, unrefined cooper and wood in the rough. Crude oil export shares 96% of the total export of Congo to China. In addition, Equatorial Guinea exports crude oil and natural gas to China. Therefore, this affirms that the major export of Africa to China is concentrated on mineral resources and other raw materials. The export of South Africa also depends on raw materials and intermediate goods (Edwards and Jenkins, 2013). China oil import from Africa covered up to 18.5% of China's global oil imports in 2014, making Africa among the largest exporter of crude oil to China (BP, 2014).

The fastest growth rate of total trade between China and Africa helps China conquest to be the first trade partner for Africa taking position held by United States for long time. In 2009 China became the first trade partner by having $90.909 billion total trade with Africa exceeding the amount of total trade with US by $4.176 billion. This is because trade with United States was declined by 38.87% in 2009 from 2008. In 2010 and 2011 Africa-US trade had slight growth registering annual growth rate of 30.7 and 11.1%, respectively. However, it had negative growth rate again in 2012 and 2013. This confirms that Africa Growth and Opportunity Act (AGOA) that was launched by US to promote bilateral trade relation between Africa and US could not achieve the expected goal. In contrast, China-Africa trade was grown at the fastest rate achieving over $209 billion in 2013 that is more than double of Africa-US bilateral trade in 2013. And as we can see from the trend of growth, the gap between Africa-China and Africa-US bilateral trade is growing.

2.2. Economic performance of some African countries

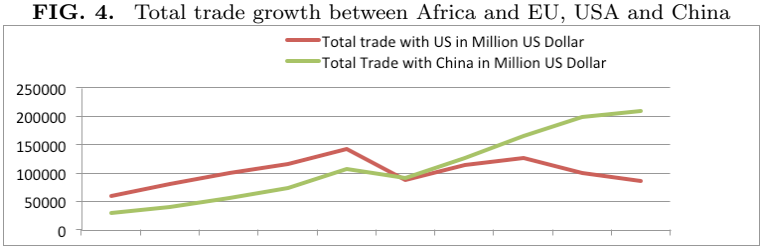
The average growth rate of real gross domestic product (real GDP) is computed for some African countries from World Development Indicator.

FIG. 3. Share of import and export of some African countries from/to China



Source: Authors, based on data from UNComtrade

FIG. 4. Total trade growth between Africa and EU, USA and China

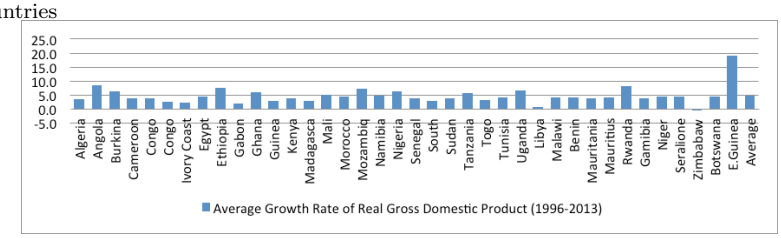


Source: Authors, based on data for Africa-U.S. trade from Census Bureau & Africa-China from Global Trade Atlas

It is positive for all countries except Zimbabwe which registered negative 0.6% average growth rate for the last two decades. Some African countries which have lower average growth rate of real GDP are Libya, Niger, Congo Democratic, Sera Leone, Ivory Coast, Nigeria, Madagascar and Mali. On the other hand, Equatorial Guinea has registered the highest average growth rate among the sample countries. Its economy was grown by 19.1% on average. This remarkable growth rate might be because it is one of the richest countries in oil and the third largest oil exporting country in Africa. Angola, Rwanda, Ethiopia and Mozambique are among the

top five countries having rank of second to fifth in terms of their economic growth. They have achieved 8.4%, 8.1%, 7.5% and 7.2% average growth rate in their GDP from 1996 to 2013, respectively. In general, the overall average growth rates of real GDP for 38 countries of Africa selected for this study is 4.68%.

FIG. 5. Average growth rate of real GDP for the periods 1996-12013 of 38 African countries



Source: Authors, based on data from World Development Indicator, World Bank

3. LITERATURE REVIEW

Trade openness among countries may particularly affect the economic situation of the countries in two main channels. That is it may directly raise economic growth through capital accumulation (adding capital to the economy) and indirectly speed up productivity growth through fostering technological transfer (Anderson and Babula, 2008).

3.1. Total factor productivity (TFP) and international trade

Technology is one of the critical economic variables to facilitate economic growth. It is seen as a key determinant of economic growth. Hence, without continuous progress in knowledge and productivity, long-run economic growth is impossible (Solow, 1956; Swan, 1956 and Le, 2008). The recent endogenous growth models show that growth rates of countries are related to international trade and its linkages associated with knowledge and technology spillovers. According to these models the role of international trade (especially intermediate goods and machinery trade) in the growth process in terms of technology transfer and improvement is valuable (Coe and Helpman, 1995). In addition, by directly stimulating the growth rate of countries either by increasing the amount of inputs available on the market or by improving the quality of intermediate goods, therefore, international trade can have a significant role for the economic progress of countries by enhancing the speed of technology transfer. Cameron, Proudman and Redding (2005) examined the role of international trade on productivity growth for England manufacturing industries. Their results show that in-

ternational trade has stimulating effect on technology transfer for England manufacturing industries.

Sun and Hashmati (2010) examined the impact of international trade on economic growth in China through analyzing the effect of foreign trade on improvement of productivity. As their results revealed both trade volume and trade structure towards high-tech exports result in positive effect on productivity improvement of different regions in China and has static and dynamic impact on national economic growth of China. The results of Isaksson (2007) which have concerned with the determinants of total factor productivity (TFP) reviewing different literatures based on micro, sectoral and macro studies. Accordingly, import which is one of the international trade components has a positive effect on TFP growth of countries. In addition, Mayer (2001) argues that international trade is one of the channels transferring technologies. More specifically, focusing on imports as a way of introducing foreign (relatively advanced) technology into domestic production for developing countries is a significant factor to enhance technology transfer. Especially, machinery and equipment relating to foreign research and development are likely transfer technology than other commodities. Söderbom and Teal (2003) analyzed openness as sources of productivity growth using panel data for 93 countries and they found a significant effect of openness on productivity growth for the sample countries. Alcala and Ciccone (2004) used import plus export to GDP in real term to assess the effect of international trade on productivity also found international trade has an economically significant and statistically robust positive effect on productivity. So, Export of goods and services enable the exchange of ideas among trading partners while imports of quality foreign goods and machineries can serve as channel of transferring foreign technology to importing countries.

However, there are some empirical researches which argue that trade integration alone may not benefit the trading countries. It should be supported by domestic absorptive capacity of technology for importing countries. For example, It is argued that the absence of good institutions in the developing world has been a major cause of slow economic growth, and that good institutions or governance are essential for long term development in the development process through helping countries utilize technology transferred through international trade. Baliamoune-Lutz and Ndikumana (2007) assessed the reason for limited growth effects of trade openness for African countries giving emphasis on the weakness of institutions of the countries. According to their results government institutions play an important role in enhancing the growth effects of international trade. Furthermore, Ben-David (1999) argues that the effect of foreign trade on transfer of knowledge to countries will be affected by the level of human capital. In the other words, the diffusion of technologies among trading economies and its posi-

tive impact on economic growth will be conditioned by their stock of human capital. Therefore, it is worthy to analyze the impact of trade openness of Africa-China on economic performance of African countries and technology transfer from China to Africa including conditional effects of trade openness.

3.2. International trade and economic growth

According to Sachs and Warner (1997) sources of slow growth in African economies among others is lack of openness to international markets. The results mainly support the claims that openness to international trade stimulates economic growth for African countries. The study of Omoju and Adesanya (2012) concludes that trade promotes growth in developing countries by conducting empirical analysis on the impact of trade and other economic variables on Nigerian economy. So, the relationship between trade openness and growth is not straightforward and simple. It promotes growth through a number of channels and integration with other determinants.

The impact of international trade on economic growth is partly affected by the institutional quality of countries. Matthew and Adegboye (2014) conducted study on the effect of trade openness, institutions and economic growth Sub-Saharan Africa and found that trade openness only had a little significance on growth in the selected countries. Baliamoune-Lutz and Ndikumana (2007) explored the causes for the limited growth effects of trade openness in Africa using Arellano- Bond GMM model analyzing panel data for African countries. The results indicate weakness of institutions is responsible to enhance the growth effect of international trade. Improving the quality of institution, therefore, boost economic growth by increasing trade benefit for the countries. In addition, human capital improvement of trading partners can increase the benefit of trade openness. Chang et al. (2009) researched the effect of trade openness on economic growth for some developed and developing countries. For them the effects of trade openness on economic growth depend on different structural characteristics of the economy. Their results reveal the effect of trade openness on economic growth for Sub-Saharan Africa might be conditional on other complementary variables such educational investment and infrastructure. Therefore, analyzing the impact of trade openness between Africa and China on economic growth of African countries through affecting total factor productivity and real GDP as dependent variables is worthwhile.

4. DATA AND METHODOLOGY

4.1. Data

This study used two years average data for the periods 1995- 2013 based on the data availability for 38 African countries. The countries are listed in Appendix B. The list and definitions of variables and data sources are given in Table 1.

TABLE 1.

Definition of variables and source of data

Variable	Definition of Variables	Source of Data
LOGRGDP	Logarithm Form of Real Gross Domestic Product (in Million US Dollar at Constant 2005 US dollar)	WDI
LOGLAB	Logarithm Form of Labor Force (in Million Labor Unit)	WDI
LOGCAP	Logarithm form of Gross Fixed Capital Formation (in Million US Dollar)	WDI
INS	Political Risk index to capture Institutional Quality of Countries $[0, 1]$	PRS
LOGHEAL	Logarithm Form of Health Expenditure Per GDP of Countries	WDI
LOGCRE	Logarithm Form of the Domestic Credit to Private sector per GDP	WDI
LOGICT	Logarithm for of Mobile Cellular Subscription (Per 100 Person)	WDI
LOGEDU	Logarithm form of Gross Secondary School Enrolment (%)	WDI
LOGOPEN	The Sum of Import from China to Africa and Export to China from Africa (in Million US Dollar) per GDP	GTA
LOGFDI	Logarithm Form of Net Inflow of FDI to Africa per GDP	WDI
OPENFDI	The Interaction of Trade Openness to China and FDI	WDI and GTA
OPENINS	The Interaction of Institutional Quality and Trade Openness to China	PRS and GTA
CORROPEN	Corruption Control * Trade Openness Africa-China	PRS and GTA
ACCOPEN	Accountability of Government * Trade Openness Africa-China	PRS and GTA
POLSOPEN	Political Stability and absence of violence * Trade Openness	PRS and GTA
RULEOPEN	Rule of Law * Trade Openness Africa-China	PRS and GTA
REGOPEN	Regulation quality * Trade Openness Africa-China	PRS and GTA
EFFOPEN	Government Effectiveness * Trade Openness Africa-China	PRS and GTA
OPENEDU	The Interaction of Education Human Capital and Trade Openness	WDI and GTA

We used the logarithm form of the sum of export to China and import from China per GDP of countries as trade openness following economic literatures such as Alcala and Ciccone (2004), Busse and Königer (2012) and Mercan et al. (2013). These studies used the ratio of the sum of export and import to GDP as proxy of trade openness. We used three interaction variables (trade openness with institutional indicators, education human capital and foreign direct investment (FDI)) to determine the conditional effect of trade openness of Africa and China on economic growth of African countries on the top of its individual effect (Chang et al., 2009; Baliamoune-Lutz and Ndikumana, 2007; Khordagui and Saleh, 2013). Trade openness

and its interaction with other variables are considered as endogenous variables in the model.

More specifically, we used the interaction of institutional quality of countries (average of all indicators and six institutional quality indicators individually) and trade openness of Africa-China to examine the significance of institutional quality of countries to be benefited from trade integration with China. Inclusion of institutional variable as one of the determinants of economic growth is based on some economic literatures. Amin (2013), Alence (2004), Kilishi et al. (2013) and Rodrik, Subramanian and Trebbi (2002) among others used institutional quality variable to analyse the impact of institutional quality on economic growth. It is shown by six indicators of political risk measuring various dimensions of the political and business environment of the countries. These indicators are Voice and accountability[1], government effectiveness[2], political stability and absence of violence[3], control of corruption[4], regulatory burden/quality[5] and rule of law[6]. The values of each indicator range from 0 to 1. The closer the value is to zero, the weaker the institutional quality and the closer it is to 1 the better the quality of institutions.

The interaction of education human capital with trade openness between Africa and China is used to incorporate the conditional effect of trade openness on technology transfer that helps increase absorptive capacity of countries (Chang et al., 2009).

In addition, the secondary school enrolment is used as a proxy of education human capital to determine the impact of education human capital on real GDP and TFP as an independent variable based on Bbaale and Mutenyo (2011), Chang et al. (2009), Gemmell (1996) and Zelleke, Sraiheen and Gupta (1996) which used secondary school enrolment to proxy education human capital. We included health expenditure to analyze the impact of health human capital on TFP of African countries and real GDP of Africa (Gisore et al., 2014 and Eggoh, Houeninvo & Sossou, 2015).

We also counted the number of mobile phone subscription per 100 people to proxy information and communication technology and to see its impact

[1]Voice and accountability shows civil liberties and political rights of citizens to participate in government selection and replacement process

[2]Government effectiveness assesses the bureaucratic quality to provide public service and the independence of civil service from political pressure, and the credibility of the government's commitment to policies to be drafted and implemented

[3]Political stability and absence of violence refers government stability, internal and external conflict and ethnic tensions

[4]The ability of government to fight against corruption

[5]regulatory quality reflects the perceptions of the ability of the government to formulate and implement sound policies and regulations that are conducive to private sector development

[6]Rule of law shows legal institutions, including access to non-discriminatory judiciary that are supportive of the principles of the rule of law

on TFP and real GDP growth. Kefela (2011) and Hyde-Clarke (2013) used mobile phone as communication technology to analyse the impact of information technology on economic growth. Finally, domestic credit to private sector to GDP and net inflow of FDI are among the variables used in the models. Domestic credit to private sector to GDP is used to proxy financial development and domestic economic stability. Labor force and physical capital are incorporated in the model used in model Two. Summary statistics of all major variables is computed in Table 5 in Appendix A.

4.2. Methods of analysis

This part is concerned with description of the estimation methods used to obtain parameters. We used two methods of panel data analysis. The first one is static panel data model conducted to calculate TFP from neoclassical economic growth model (Solow, 1956). The second one is two-step system Generalized Method of Moments (GMM) estimator of Arellano and Bover (1995) and Blundell and Bond (1998) for dynamic panel data analysis. The second estimator is employed to account for the direct impact of trade openness of African countries and China on the economic growth for African countries using extended economic growth model of Mankiw, Romer and Weil (1992) including all variables listed in this study on the top of physical capital, labor force and human capital and, to determine the effects of Africa-China trade openness on TFP of African countries.

Since our model for estimation of the effect of trade openness of Africa-China on real GDP and TFP of African countries is based on a pooled data set of cross-country and time-series observations, two-step GMM system estimator is more relevant. This is because the empirics of long-run economic growth are based on a cross-section regression framework. In addition, economic growth by itself is a dynamic phenomenon. Therefore, to analyse this dynamic behaviour of economic growth system GMM model more appropriate since it can address the problem and gives consistent estimates even in the presence of measurement error and endogenous right handside variables. In addition, this model provides asymptotically efficient inference assuming a minimal set of statistical assumptions. This method also expresses each observation as the deviation from the average of the future observations in the sample for the same individual and weights each deviation to standardize the variance plus it eliminates individual effects by computing orthogonal forward deviation (Arrelano and Bover, 1995 and Blundell and Bond, 1998). The following part briefly explains the models estimated in the study.

4.2.1. The impact of trade openness of Africa-China on TFP of African countries

Before we specify the estimation model of the impact of trade openness of African and China, we need to calculate TFP for African countries. There are different approaches to measure TFP. Among the approaches we used the regression based approach that assumes a specific form of production function and estimates the parameters of it using the input and output data. If there is no model specification problem and data, it can avoid measurement problems related to labor shares in the model (Park, 2010). To calculate TFP first we need to estimate parameters of production function. That mean output elasticity can be calculated from the function and, in turn, TFP can be derived. This study assumes a two-input production function. TFP growth is calculated based on the Solow (1956) growth model that he conducted to show the relationship between production (Y_t) and factor of production such as physical capital (K_t), labor force (L_t) and technology (A_t) is shown as per the following Cobb- Douglas specifications of production function. TFP in this case is the residual of the growth model.

$$Y(K_t, L_t, A_t) = A_t K_t^{\alpha} L_t^{\beta} \tag{1}$$

Transforming the above model to natural logarithm form, it can be specified as:

$$\ln Y(K_t, L_t, A_t) = \ln[A_t K_t^{\alpha} L_t^{\beta}] \tag{2}$$

$$\ln Y(K_1, L_t, A_t) = \ln A_t + \ln K_t^{\alpha} + \ln L_t^{\beta} \tag{3}$$

For our panel model specification we rewrite the function as:

$$\ln Y_{it}(K_{it}, L_{it}, A_{it}) = \ln A_{it} + \alpha \ln K_{it} + \beta \ln L_{it} \tag{4}$$

$$TFP_{it} = \ln A_{it} \tag{5}$$

$$= \ln Y_{it}(K_{it}, L_{it}, A_{it}) - \alpha \ln K_{it} - \beta \ln L_{it}$$

Where, α is elasticity of output to the capital stock, β measures elasticity of output to labor, i is for different countries and t is time in year. We assumed increasing returns to scale or decreasing returns to scale ($\beta + \alpha \neq 1$). Finally, we can calculate TFP for the sample countries for the given period of time using the following equation.

$$TFP_{it} = \ln A_{it} = \ln Y_{it}(K_{it}, L_{it}, A_{it}) - \alpha \ln K_{it} - \beta \ln L_{it} \tag{6}$$

Another issue to be addressed here is about capital stock data. Since we cannot find data for capital stock, we ought to calculate it from gross fixed capital formation data found from World Development Indicator. We adopted the method used by Alvi (2013) to calculate capital stock.

$$K_I = \frac{G_r F_i K_I}{\delta + \theta} \tag{7}$$

Where, K_I is initial capital stock, $G_r F_i K_I$ represents gross fixed capital formation, δ is depreciation rate for capital per year and θ represents average growth rate of gross fixed capital formation. We used 5 percent depreciation rate. Annual series data for capital stock for each year could be calculated using:

$$K_t = K_{t-1} - \delta K_{t-1} + G_r F_i K_t \tag{8}$$

Where, K_t a capital stock is at current year, K_{t-1} is capital stock in previous year; $G_r F_i K_t$ is the real gross fixed capital formation.

Finally, GMM System Estimator is run to analyze the impact of trade openness between Africa and China on TFP of African countries as per the Equations 9 and 10.

$$\begin{aligned} TFP_{it} &= \alpha_0 + \alpha_1 EDU_{it} + \alpha_2 OPEN_{it} + \alpha_3 FDI_{it} + \alpha_4 INS_{it} \\ &+ \alpha_5 OPENEDU_{it} + \alpha_6 OPENINS_{it} + \alpha_7 OPENFDI_{it} \\ &+ \alpha_8 CRE_{it} + \alpha_9 ICT_{it} + \alpha_{10} HEAL_{it} + \varepsilon_{it} \end{aligned} \tag{9}$$

Logarithm-linear transformation of the above equation can be written as follows:

$$\begin{aligned} \log TFP_{it} &= \alpha_0 + \alpha_1 \log EDU_{it} + \alpha_2 \log OPEN_{it} + \alpha_3 \log FDI_{it} + \alpha_4 INS_{it} \\ &+ \alpha_5 OPENEDU_{it} + \alpha_6 OPENINS_{it} + \alpha_7 OPENFDI_{it} \\ &+ \alpha_8 CRE_{it} + \alpha_9 \log ICT_{it} + \alpha_{10} \log HEAL_{it} + \varepsilon_{it} \end{aligned} \tag{10}$$

4.2.2. The impact of Africa-China trade openness on real GDP growth of African countries

The effect of trade openness of Africa-China on economic growth of African countries using real GDP growth rate as a dependent variable is

specified in the following equations using two-step system GMM estimator.

$$\begin{aligned}\log RGDP_{it} &= \beta_0 + \beta_1 \log LAB + \beta_2 \log CAP + \beta_3 \log EDU_{it} + \beta_4 \log ICT_{it} \\ &+ \beta_5 \log CRED_{it} + \beta_6 \log FDI_{it} + \beta_7 INS_{it} + \beta_8 \log OPEN_{it} \\ &+ \beta_8 OPENEDU_{it} + \beta_9 OPENINS_{it} + \beta_{10} OPENFDI \\ &+ \beta_{11} \log HEAL_{it} + \eta_{it} \qquad (11)\end{aligned}$$

Furthermore, we used Sargan test to test over identification restriction of two-step system GMM model[7]. Arellano and Bond test is used for autocorrelation[8]. In addition, Wald test is conducted for overall fitness of the model[9].

5. RESULTS AND FINDINGS OF THE STUDY

This section presents empirical results of the study. In the first part we report the calculation of TFP and estimated effects of trade openness of Africa-China on TFP. Second, we present the estimation results of the effect of trade openness of Africa-China on real GDP growth of African countries.

5.1. The effects of trade openness of Africa-China on TFP of African countries

We used Fixed Effect model to estimate TFP from Solow (1956) growth model considering technology as a residual. Hausman test was conducted to choose between Fixed Effect Model (FEM) and Random Effect Model (REM). According to the results of the test, we failed to reject FEM. Thus we conducted FEM. Figure 6 presents the growth trend of TFP for the countries derived from the coefficients of the fixed effect model and growth rate of TFP for each country computed in Table 6 in Appendix A.

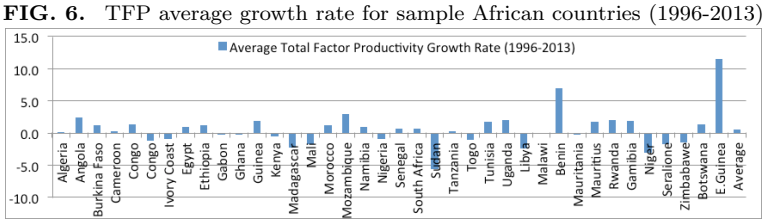
The growth rate of TFP for the sample countries is mixed. It is computed from regression results of FEM. It is negative for some of the countries and positive for other countries. The lowest average growth rate of TFP is

[7]In standard sargan test the null hypothesis is over identifying restrictions are valid against the alternative of over identifying restrictions are not valid (Arellano and Bond, 1991). If the model is no over identification restriction problem, null hypothesis will be accepted.

[8]Arellano and Bond (1991) suggest two (AB1 and AB2) autocorrelation tests to test the validity of the model. However, most importantly null hypothesis of no second order serial correlation should be accepted to consider the model is valid model.

[9]In the Wald statistic the null hypothesis that all the coefficients except the constant are zero against the alternative hypothesis of all the coefficients different from zero. If we fail to reject alternative hypothesis, the overall fitness of the model is good.

FIG. 6. TFP average growth rate for sample African countries (1996-2013)



Source: Authors, based on FEM regression results

registered for Sudan. Its average growth rate is −5.6% that might be because of political instability in the country. The other countries which have negative average growth rate of TFP are Libya, Niger, Congo Democratic, Sera Leone, Zimbabwe, Ivory Coast, Nigeria, Madagascar and Mali. Their GDP growth rate is also lower compared to other countries. On the other hand, Equatorial Guinea has registered the highest average growth rate of TFP among the sample countries. Its productivity was grown by 11.5% on average for the periods 1996-2013. Its real GDP was also grown by 19.1 percent (Figure 5). Angola, Rwanda, Ethiopia and Mozambique have also registered positive average growth rate in their productivity which might contribute for their growth. However, the largest economies in Africa such as Nigeria, South Africa and Egypt have no remarkable growth in TFP for the time horizon used for this study. In general, the overall average growth rate of TFP for sample countries is 0.57%. Table 2 reports the results obtained from the two-step system GMM regression for TFP. We used two years average data for the periods 1995-2013 in order to avoid the problem of missing data.

In column (1), we have regressed using Africa-China trade openness and its interaction with different variables such as education human capital, FDI and average of institutional quality variables. In column (2), we added some additional variables that can determine TFP of countries. That is in addition to trade openness and its interaction with other variables mentioned above, we included logarithm form of mobile subscribers per 100 person, logarithm form of domestic credit to private and logarithm form of health expenditure. In column (3), we run the model without education human capital and its interaction with trade openness of Africa-China to see whether there is change in the sign of trade relationship between Africa and China since there is multicollinearity between interaction variables of trade openness of Africa-China and education human capital variable and the interaction of it with institutional quality variable since their correlation is 0.9 (Table 7 in Apendix A). In addition, in column (6) and (7) we

TABLE 2.

Two-step system GMM estimates of the effects of trade openness of Africa-China on TFP of African countries

Dependent Variable: Logarithm form of TFP

Variables	(1) System GMM	(2) System GMM	(3) System GMM	(4) OLS	(5) FEM	(6) System GMM	(7) System GMM
$LOGTFP_{t-1}$	0.228^{***}	0.205^{***}	0.211^{***}	0.205^{***}	0.813^{***}	0.129^{***}	0.109^{***}
	(0.005)	(0.006)	(0.006)	(0.052)	(0.037)	(0.008)	(0.007)
LOGEDU	0.026^{***}	0.044^{***}		-0.027	-0.039	0.044^{***}	
	(0.004)	(0.009)		(0.037)	(0.043)	(0.008)	
LOGOPEN	-0.146^{***}	-0.212^{***}	-0.153^{***}	-0.092^{*}	-0.086	-0.186^{***}	-0.282^{***}
	(0.019)	(0.034)	(0.017)	(0.053)	(0.058)	(0.041)	(0.028)
LOGFDI	0.028^{**}	0.043^{**}	0.033^{***}	0.076	0.165^{**}	0.037	-0.006
	(0.014)	(0.017)	(0.010)	(0.059)	(0.068)	(0.024)	(0.013)
INS	0.264	0.495^{*}	0.327^{***}	1.023^{*}	0.162	0.099	1.380^{***}
	(0.201)	(0.286)	(0.044)	(0.571)	(0.621)	(0.340)	(0.245)
OPENEDU	0.014^{***}	0.019^{***}		-0.009	-0.012	0.020^{***}	
	(0.001)	(0.002)		(0.009)	(0.010)	(0.002)	
OPENINS	-0.065^{*}	0.010^{**}	0.030^{***}	0.110	0.020	-0.040	0.193^{***}
	(0.034)	(0.053)	(0.009)	(0.128)	(0.151)	(0.058)	(0.044)
OPENFDI	0.004	(0.004)	0.005^{*}	0.019	0.040^{**}	0.010^{*}	0.003
	(0.003)	0.001	(0.003)	(0.013)	(0.015)	(0.005)	(0.004)
LOGICT		0.033^{***}	0.034^{***}	-0.013	-0.007	0.039	0.044^{***}
		(0.006)	(0.004)	(0.014)	(0.015)	(0.008)	(0.006)
LOGHEAL		-0.201^{***}	-0.229^{***}	-0.161	-0.073	-0.147^{**}	-0.153^{**}
		(0.042)	(0.024)	(0.146)	(0.059)	(0.068)	(0.063)
LOGCRED		-0.011	0.013	-0.012	0.082^{***}	0.078^{**}	0.024
		(0.024)	(0.015)	(0.062)	(0.031)	(0.033)	(0.028)
Constant	3.008^{***}	3.186^{***}	3.676^{***}	3.461^{***}	0.394	3.424^{***}	3.050^{***}
	(0.0105)	(0.192)	(0.076)	(0.439)	(0.303)	(0.234)	(0.187)

run for other African countries excluding Angola and South Africa with and without human capital and its interaction with Africa- China trade openness variable because the volume of bilateral trade between Angola-China and South Africa- China is larger than the rest of African countries. In all specifications the sign of the coefficient of trade openness between Africa and China is negative and statistically significant though there is change in magnitude of the coefficient.

In addition, we also run Ordinary Least Square (OLS) and FEM in column (4) and (5), respectively. Bond, Hoeffler and Temple (2001) ar-

TABLE 2—*Continued*

Sargan (Ch2-stat)	(29.837)	(26.793)	(28.652)			(18.779)	(25.650)
p-value	0.6719	0.8057	0.7271			0.984	0.849
Wald (Ch2-stat)	(11417.70)	(1062.05)	(1258.87)			(2584.77)	(1293.27)
p-value	0.000	0.000	0.0000			0.000	0.000
AB2 (Ch2-stat)	(−1.264)	(−0.3636)	(−0.0350)			(−.5117)	(0.468)
p-value	0.2064	0.7162	0.9720			0.609	0.640
Obs.	251	245	249	273	273	232	235
Group	33	33	33	33	33	31	31

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, standard error in parenthesis, AB2 test are Arellano and Bond tests for second order serial correlation, Obs: observations $LOGTFP_{t-1}$: logarithm form of lag of TFP (dependent variable)

gued that Ordinary Least Square and within FEM estimations of dynamic growth models provide the upper and lower bands for the autoregressive parameter of the lagged variable of dependent variable to be consistent although they are not appropriate estimators for this study. Ordinary Least Square regression results in column (6) shows that the coefficient of lagged TFP is 0.813. That is the greatest to all coefficients of lagged TFP in the estimators excluding column (6) and (7). In opposite, the coefficient of lagged value of dependent variable is biased downward in FEM. From column (5) where fixed effect model results are given, the coefficient of lagged TFP is 0.205. So, the consistent estimates of system GMM should be between these two values. The coefficient of lag of dependent variable is in between in these values in column (1) to (3). Its coefficients are positive and statistically significant at 1 percent level of significance. In addition, it is less than one in all models for dynamic stability. It indicates that the dependent variable is serially correlated. So, the lagged TFP should be included in the model to omit biased fixed effects estimates.

Furthermore, we fail to reject insignificant statistics for Sargan test for all system GMM in the Table 2. Therefore, it confirms that the instruments satisfy the orthogonality condition or all instruments are valid in the model. Similarly, the Wald test for joint significance of the variables does not reject our model specification. The serial correlation test does not reject the null that there is no second order serial correlation. These diagnostic tests, therefore, validate the use of the two-step system GMM model to analyze the impact of variables on TFP. So we can interpret our coefficients of the regression.

Africa-China trade openness has negative and statistically significant impact on TFP for African countries. The coefficient of it shows elasticity

since it is in natural logarithm form. That is one percent increase in trade openness between Africa and China decreases TFP of African countries by 0.146%, 0.212% and 0.153% at 1% level of significance in column 1, 2 and 3, respectively when we consider it individually. This might be because technology embodied by trade should be backed by domestic adaptive capacity to use benefit of trade openness between Africa and China to excel economic growth. That is trade openness of Africa and China alone is not sufficient for African countries to reap the benefits of trade openness. To opposite to the coefficient of trade openness to Africa-China alone, the interaction of trade openness with overall institutional quality has robust positive impact on total factor productivity for African countries (Table 2). That is one percent change in the interaction variable (OPENINS) changes TFP of African countries by 0.03% in the same direction (Column 3). In addition, the impact of each institutional quality variables on TFP is presented in Table 3. As the results indicate the interaction of trade openness to China and corruption control, regulatory quality and rule of law have negative significant effect on TFP of African countries. However, democratic accountability, political stability and absence of violence and government effectiveness interaction with trade openness of Africa-China have robust positive effect on TFP of African countries.

So, this result would indicate that the capability of African countries to benefit from trade openness between Africa and China is made by the quality of their institutions since trade openness promotes productivity improvement as institutional quality increases. Therefore, Ability of the government to formulate and implement sound policies and regulations that are conducive to private sector and government capacity to keep political stability and avoiding ethnic tensions and internal and external conflict is worthwhile for African countries to realize trade benefit to them. Furthermore, effectiveness to evaluate the bureaucratic quality and governments commitment to policies are important to efficiently utilize productivity enhanced technology transfer from China. Increase in trade openness between Africa and China, hence, should be backed by good domestic institutions to change the impact of trade to positive. So, overall improvement in institutional quality is critical tool to benefit African countries from bilateral trade with China.

The other variable that has significant positive effect on TFP of African countries is the interaction of trade openness of Africa-China and education human capital. Its effect is statistically significant at 1% level of significance. So, education human capital has a role to properly use imported technology to boost productivity because it can facilitate technology imple-

TABLE 3.

Two-step system GMM estimates of the joint effects of Africa-China trade openness and individual institutional quality indicators on TFP

Dependent Variable: Log of TFP

Variables	(6) Corruption control	(7) Accountability stability	(8) Political	(9) Rule of law quality	(10) Regulatory effectiveness	(11) Govern
$LOGTFP_{t-1}$	0.485***	0.411***	0.411***	0.388***	0.383***	0.405***
	(0.005)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
LOGOPEN	−0.005	−0.091***	−0.106***	−0.0002	−0.044***	−0.132***
	(0.003)	(0.001)	(0.002)	(0.007)	(0.002)	(0.002)
CORROPEN	−0.201***					
	(0.007)					
ACCOPEN		0.012***				
		(0.002)				
POLSOPEN			0.029***			
			(0.004)			
RULEOPEN				−0.151***		
				(0.012)		
REGOPEN					−0.071***	
					(0.003)	
EFFOPEN						0.159***
						(0.007)
Constant	2.184***	2.504***	2.502***	2.631***	2.633***	2.555***
	(0.024)	(0.009)	(0.011)	(0.014)	(0.014)	(0.008)
Sargan (Ch2-stat)	(32.302)	(31.788)	(32.003)	(31.911)	(32.462)	(32.135)
p-value	0.551	0.5765	0.566	0.570	0.543	0.559
Wald (Ch2-stat)	(12161.22)	(8732.49)	(2588.58)	(9746.84)	(38115.87)	(4800.40)
p-value	0.000	0.000	0.000	0.000	0.000	0.000
AB2 (Ch2-stat)	(0.333)	(0.3228)	(0.288)	(1.009)	(0.432)	(0.4781)
p-value	0.739	0.7468	0.774	0.313	0.666	0.633
Obs.	261	261	261	261	261	261
Group	33	33	33	33	33	33

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, standard error in parenthesis, AB1&2 test are Arellano and Bond tests for autocorrelation, Obs: observations $LOGTFP_{t-1}$: lag of TFP (dependent variable)

mentation and adoption for African countries. This also confirms that in addition to facilitating trade integration between Africa and China, improving educational level (improving human capital accumulation) of African countries is important to benefit from trade openness between Africa and China. Therefore, to reap the benefit of trade openness to China, African

countries need strong domestic absorptive capacity and the ability to adapt imported technology by improving the human capital level.

Net inflow of foreign direct investment to Africa has also significant positive effect on TFP. It is because domestic firms may use technologies imported by foreign firms introduced through imitation, receiving important information from switching employers from foreign companies to local owned companies or having linkage to multinational firms that are potential suppliers of intermediate goods or buyers of their own products. However, we found that the interaction of trade and foreign direct investment has negative significant effect on TFP of African countries. Other variable that has robust positive effect on TFP is information communication technology in terms of mobile subscription. However, health expenditure has negative significant impact on TFP in Africa.

5.2. The effects of trade openness of Africa-China on real GDP growth of African countries

Table 4 presents the system GMM estimates of the effects of trade openness of Africa and China on real gross domestic product of African countries. In column (1), we analyzed the impact of trade openness between Africa and China using two years average data for the period of 1995-2013. In column (2), we present GMM regression results estimated without education and institutional variables and their interaction to see the change on the sign of the coefficient of Africa-China trade openness since they have some missing values. In column (3) we omitted education human capital and its interaction with trade openness of Africa-China since there is multicollinearity between institutional variable and education variable. We also estimated the model without South Africa and Angola which are outliers in the sample having more share of total trade with China compared to other African countries. The results are presented in column (6) and (7) with and without including education human capital and its combination with that of Africa-China trade openness. In all these regressions, the coefficient of Africa-China trade openness variable is negative and statistically significant. It has positive and significant impact on real GDP growth of African countries at 1% level of significance in column (1), (2) and (3). However, its effect on real GDP growth of the countries is insignificant in column (7) when we exclude education human capital and its interaction with trade openness variable without South Africa and Angola. Column (4) and (5) represent OLS and FEM, respectively to compare initial of dependent variable (lag of dependent variable). In all first three models the lag of dependent variable which is used as a proxy for the initial condition

TABLE 4.

Two-step system GMM estimates of the effects of Africa-China trade openness on real GDP growth rate of African countries, two years average of the periods 1995-2013

Dependent Variable: Growth rate of real GDP (RGDPr)

Variables	(1) System GMM	(2) System GMM	(3) System GMM	(4) OLS	(5) FEM	(6) System GMM	(7) System GMM
$GRGDPr_{t-1}$	0.210^{***}	0.225^{***}	0.225^{***}	0.678^{***}	0.033	0.151^{***}	0.134^{***}
	(0.045)	(0.002)	(0.002)	(0.032)	(0.029)	(0.002)	(0.001)
LOGLABOR	0.056^{***}	0.059^{***}	0.065^{***}	0.013^{***}	0.042^{***}	0.043^{***}	0.043^{***}
	(0.004)	(0.003)	(0.004)	(0.004)	(0.010)	(0.005)	(0.002)
LOGCAP	0.142^{***}	0.156^{***}	0.144^{***}	0.195^{***}	0.107^{***}	0.141^{***}	0.146^{***}
	(0.003)	(0.001)	(0.001)	(0.024)	(0.013)	(0.005)	(0.003)
LOGEDU	0.076^{***}		0.067^{***}	-0.072	0.033	0.072^{***}	
	(0.009)		(0.006)	(0.050)	(0.028)	(0.010)	
LOGICT	0.040^{***}	0.055^{***}	0.065^{***}	0.030^{*}	0.025^{**}	0.044^{***}	0.056^{***}
	(0.009)	(0.004)	(0.005)	(0.018)	(0.011)	(0.009)	(0.005)
LOGCRED	0.193^{***}	0.162^{***}	0.138	0.044	0.107^{**}	0.121^{***}	0.156^{***}
	(0.021)	(0.008)	(0.009)	(0.039)	(0.048)	(0.028)	(0.019)
LOGFDI	0.140^{***}	0.127^{***}	0.116^{***}	0.092	0.105^{**}	0.147^{***}	0.201^{***}
	(0.024)	(0.009)	(0.019)	(0.081)	(0.045)	(0.036)	(0.020)
INS	0.624^{**}			0.608	0.735^{*}	-0.032	1.065^{***}
	(0.259)			(0.730)	(0.432)	(0.215)	(0.235)
LOGOPEN	0.224^{***}	0.118^{***}	0.194^{***}	0.116^{*}	0.077^{*}	0.148^{**}	0.230
	(0.040)	(0.008)	(0.009)	(0.069)	(0.041)	(0.049)	(0.024)
OPENEDU	0.028^{***}		0.029^{***}	-0.024^{**}	0.012^{*}	0.027^{***}	
	(0.003)		(0.002)	(0.012)	(0.007)	(0.004)	
OPENINS	0.127^{**}			0.205	0.083	-0.016	0.210^{***}
	(0.056)			(0.178)	(0.096)	(0.045)	(0.045)
OPENFDI	0.032^{***}	0.028^{***}	0.026^{***}	0.022	0.023^{**}	0.032^{***}	0.045^{***}
	(0.006)	(0.002)	(0.005)	(0.018)	(0.010)	(0.008)	(0.004)
LOGHEAL	-0.066^{***}	-0.063^{***}	-0.129^{***}	-0.047	-0.049	0.046	0.004
	(0.023)	(0.018)	(0.023)	(0.072)	(0.112)	(0.034)	(0.026)
Constant	4.449^{***}	4.630^{***}	4.661^{***}	0.897^{**}	7.130^{***}	5.481	4.977^{***}
	(0.384)	(0.025)	(0.046)	(0.375)	(0.397)	(0.288)	(0.120)

is in between the coefficients of Ordinary Least Square and Fixed models. That is they are in between 0.678 (the magnitude of the coefficients of lagged of dependent variable in OLS) and 0.033 (the magnitude of the coefficient of lagged of dependent variable in FEM), respectively.

TABLE 4—*Continued*

Sargan(Ch2sta)	(24.386)	(32.649)	(30.756)			(19.539)	(25.607)
p-value	0.8879	0.534	0.6274			0.978	0.8493
Wald(Ch2-stat)	(1.6e+06)	(2.8e+06)	(1.8e+06)			(1.8e+06)	(1.5e+05)
p-value	0.000	0.000	0.000			0.000	0.000
AB2 (Ch2-stat)	(−0.203)	(0.824)	(0.116)			(.360)	(.550)
p-value	0.839	0.410	0.908			0.7187	0.576
Obs.	248	284	280	277	276	235	238
Group	33	38	38	33	33	31	31

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, standard error in parenthesis, AB1&2 test are Arellano and Bond tests for autocorrelation, Obs: observations $GRGDPr_{t-1}$: lag of RGDPr (dependent variable).

Therefore, this result indicates that Africa-China trade openness should be more strengthen to guarantee economic growth for African countries. In addition, we analyzed the conditional effects of trade openness with other variables because the channels that trade flow are many and complex. As a result, we used the interaction of trade openness to institutional, human capital and foreign direct investment variables to determine its conditional impact. Accordingly, the interactions of trade openness with institutional quality, human capital and foreign direct investment have positive and significant effect on economic growth. This shows that trade openness to China benefits Africa by stimulating their economic growth.

The other variables that affect real GDP growth of African countries are physical capital, labor force, education human capital, information communication technology infrastructure, the access of domestic credit to private sector, net inflow of foreign direct investment and institutional quality variables. These variables have robust positive impact on real GDP growth of African countries. However, expenditure on health has negative significant effect on economic growth for African countries. This might be because of inefficiency of public spending on health due to bureaucracy and underinvestment in the sector (Eggoh et al, 2015).

6. CONCLUSIONS AND RECOMMENDATION

This study has examined the impact of trade openness of Africa-China on factor productivity and economic growth of Africa using a two-step system GMM model. More specifically, we estimated two models. The first model is used to determine the effects of trade openness between Africa and China on TFP growth of African countries and the second model is used to show

its effect on real GDP growth of African countries using extended economic growth model of Mankiw et al. (1992) to include different determinants of economic growth. We used two years average data for the periods 1995-2013 for 38 African countries. This study is the first to examine the dynamic effects of Africa-China trade openness on technology transfer using dynamic panel data model. In addition, we looked at the joint effect of Africa-China trade openness and institutional quality of African countries using institutional quality variables from political risk index of African countries. Furthermore, we have also taken in to account interaction of Africa-China trade openness and human capital variable of African countries.

The results of this study show that Africa-China trade openness has robust positive effect on real GDP growth of African countries. In addition, the results of study reveal that the interaction of Africa-China trade openness with institutional quality variable has positive significant effect on TFP of African countries. The results also reveal that the joint effect of Africa-China trade openness and human capital is robust positive on productivity improvement and economic growth of Africa. In addition, the interaction of trade openness and net inflow of foreign direct investment to Africa has positive significant effect on real GDP growth of African countries though its effect on TFP is insignificant. However, the individual effect of trade openness between Africa and China on TFP of Africa is negative and significant. That is trade openness between Africa and China promotes technology improvement and economic growth for African countries by strengthening institutional capacity and the level of human capital of the African countries. The other variables that have positive and significant effect on TFP of African countries are mobile subscription used as proxy of information technology infrastructure and education human capital. But the impact of health expenditure on TFP and real GDP growth is negative and significant. This study also disclose that in addition to the conditional effect of trade openness between China and Africa, labor force, human capital, credit to private sector, net inflow of foreign direct investment, institutional quality and physical capital accumulation are variables impacting real GDP growth of African countries positively at a significant level.

To benefit from Africa-China trade openness for productivity improvement, therefore, African countries should have to build strong domestic institutions. In addition, boosting an effort to increase human capital level is recommended to efficiently utilize technology embodied in Africa-China trade openness.

APPENDIX A

TABLE 1.

Summary statistics of the some important variables two years average for the periods 1995-2013

Variables	Mean	Std.Dev. Overall	Std. Dev. Between	Std.Dev. Within	Min	Max	Obs.
FDI	4.193	9.390	5.256	7.811	−8.589	161.824	715
HEAL	5.221	1.968	1.743	0.956	1.446	13.792	703
CREDIT	22.398	25.877	24.684	7.018	0.683	160.125	681
ICT	27.231	37.219	15.488	33.922	0	214.75	717
EDU	41.357	25.044	21.846	8.041	5.165	110.764	436
INS	0.492	0.112	0.106	0.041	0.107	0.801	495
LABOR	8.291	9.377	9.299	1.901	0.224	54	722
CAP	4910.49	8784.11	8147.85	3612.10	−31	68000	712
RGDP	25003.04	47185.22	46045.72	12209.81	300	320000	718
OPENESS	0.079	0.142	0.089	0.111	0.00031	1.239	718

Note: summary statistics of all variables except openness and INS is computed from World Development Indicator Data of World Bank; summary statistics of Africa-China openness and Institutional quality is computed from Global Trade Atlas and PRS, respectively.

TABLE 2.

TFP results from FEM

R.sq: Within = 0.137		Observations=228 Wald chi2(2) = 124.44p-value:0.000		
Between=0.67		No. of groups=38		
Overall =0.52				
Variables	Coefficients	Std. Error	z-value	P-value$> z$
LogCAPSTOCK	0.27	0.04	6.49	0.000
LogLABOR	0.59	0.09	6.80	0.000
Cons.	−2.48	1.28	−1.94	0.052

Sigma_u: 0 .49

sigma_e: 0.74

rho : 0.31 (fraction of variance due to u_i)

Hausman fixed random: $\chi^2(2) = (bB)'[(V_b - V_B)^{(} - 1)](b - B) = 172.49$, $Prob > \chi^2 = 0.0000$

TABLE 3.

Correlation coefficients

	LOGFP	LAGLOGTFP	LOGEDU	LOGICT	LOGRED	LOGHEAL	LOGFDI	LOGOPEN	OPENEDU	OPENFDI	OPENINS	INS
LOGTFP	1											
LAGLOGTFP	0.99	1										
LOGEDU	0.51	0.50	1									
LOGICT	0.24	0.24	0.50	1								
LOGCRED	0.54	0.53	0.61	0.40	1							
LOGHEAL	0.05	0.05	−0.01	0.33	0.36	1						
LOGFDI	−0.25	−0.25	−0.01	0.24	−0.19	0.06	1					
LOGOPEN	−0.09	−0.08	0.15	0.58	−0.02	0.08	0.39	1				
OPENEDU	−0.32	−0.31	−0.36	0.29	−0.31	0.10	0.34	0.86	1			
OPENFDI	0.19	0.19	0.01	−0.15	0.10	−0.09	−0.90	−0.10	−0.06	1		
OPENINS	−0.14	−0.12	−0.08	0.38	−0.24	−0.02	0.35	0.91	0.90	−0.07	1	
INS	0.21	0.19	0.38	0.12	0.56	0.22	−0.21	−0.41	−0.57	0.04	−0.71	1

APPENDIX B

The List of Sample African Countries

Algeria, Angola, Benin, Botswana, Burkina Faso, Cameroon, Congo Democratic, Congo, Egypt, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sera Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda and Zimbabwe

REFERENCES

Adisu, Kinfu, Thomas Sharkey, and Sam C. Okoroafo, 2010. The Impact of Chinese Investment in Arica. *International Journal of Business and Management* **5(9)**, 3-9.

Alcala, Francisco, and Antonio Ciccone, 2004. Trade and Productivity. *Quarterly Journal of Economics* **119(2)**, 613-646.

Alence, Rod, 2004. Political Institutions and Developmental Governance in sub-Saharan Africa. *J. of Modern African Studies* **42(2)**, 163-187.

Alvi, Shahzad, 2013. Analyzing the Impact of Health and Education on Total Factor Productivity: A Panel Data Approach. *Asian-Africa Journal of Economics and Econometrics* **13(2)**, 277-292.

Amin, Aloysius Ajab, 2013. Africas Development: Institutions, Economic Reforms and Growth. *International Journal of Economics and Financial Issues* **3(2)**, 324-336.

Andersen, Lill, and Ronald Babula, 2008. The Link between Openness and Long-Run Economic Growth. *Journal of international commerce and economics*, 1-20.

Arellano, Manuel, and Olympia Bover, 1995. Another Look at the Instrumental Variable Estimation of Error-Components Models. *Journal of Econometrics* **68**, 29-51.

Baliamoune-Lutz, Mina, and Léonce Ndikumana, 2007. The Growth Effects of Openness to Trade and the Role of Institutions: New Evidence from African Countries. University of Massachusetts Amherst Working Paper no. 05.

Bbaale, Edward, and John Mutenyo, 2011. Export Composition and Economic Growth in Sub-Saharan Africa: A Panel Analysis. *The Journal of Sustainable Development* **6(1)**, 1-19.

Ben-David, Dan, 1999. Teach your Children Well: Planting the Seeds of Education and Harvesting the Benefits of Trade. Tel-Aviv University Paper no. 2000-5.

Blomstrom, Magnus, 1986. Foreign Investment and Productive Efficiency: The Case of Mexico. *Journal of Industrial Economics* **35(1)**, 97-110.

Blundell, Richard, and Stephen Bond, 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics* **87(1)**, 115-143.

Bond, Stephen, Anke Hoeffler, and Jonathan Temple, 2001. GMM Estimation of Empirical Growth Models. Nuffield College Economics Working Papers no. 2001-W21.

BP, 2014. The Statistical Review of World Energy: http://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-full-report.pdf.

Brückner, Markus, and Daniel Lederman, 2012. Trade Causes Growth in Sub-Saharan Africa. The World Bank Policy Research Working Paper no. 6007.

Busse, Matthias, and Jens Königer, 2012. Trade and Economic Growth: A Reexamination of the Empirical Evidence. HWWI Research Paper no. 123.

Busse, Matthias, Ceren Erdogan, and Henning Mühlen, 2014. China's Impact on Africa- The Role of Trade, FDI and Aid. IEE Working Paper no. 206.

Cameron, Gavin, James Proudman, and Stephen Redding, 2005. Technological Convergence, R&D, Trade and Productivity Growth. *European Economic Review* **49(3)**, 775-807.

Chang, Roberto, Linda Kaltani, and Norman V. Loayza, 2009. Openness can be Good for Growth: The Role of Policy Complementarities. *Journal of Development Economics* **90**, 33-49.

Coe, David Theodore, and Elhanan Helpman, 1995. International R&D Spillovers. *European Economic Review* **39(5)**, 859-887.

Edwards, Lawrence, and Rhys Jenkins, 2013. The impact of Chinese Import Penetration on the South African Manufacturing Sector. Southern Africa Labour and Development Research Unit Working Paper no. 102.

Eggoh, Jude, Hilaire Houeninvo and Gilles-Armand Sossou, 2015. Education, Health and Economic Growth in African Countries. *Journal of Economic Development* **40(93)**, 93-111.

Elu, Juliet U., and Gregory N. Price, 2010. Does China transfer Productivity Enhancing Technology to Sub-Saharan Africa? Evidence from manufacturing firms. *African Development Review* **22(S1)**, 587-598.

Gemmell, Norman, 1996. Evaluating the Impacts of Human Capital Stocks and Accumulation on Economic Growth: Some New Evidence. *Oxford Bulletin of Economics and Statistics* **58(1)**, 9-28.

Gisore, Naftaly, Symon Kiprop, Aquilars Kalio, and James Ochieng, 2014. Effect of Government Expenditure on Economic Growth in East Africa: A Disaggregated Model. *European Journal of Business and Social Sciences* **3(8)**, 289-304.

He, Yong, 2013. Does China's Trade Expansion Help African Development?-An Empirical Estimation. *China Economic Review* **26**, 28-38.

Henry, Michael, Richard Anthony Kneller, and Chris Robert Milner, 2003. Trade, Technology Transfer and National Efficiency in Developing Countries. GEP Researcher Paper no. 50.

Hyde-Clarke, Nathalie, 2013. The Impact of Mobile Technology on Economic Growth amongst 'Survivalists' in the Informal Sector in the Johannesburg CBD, South Africa. *International Journal of Business and Social Science* **4(16)**, 149-156.

Isaksson, Anders, 2007. Determinants of total factor productivity: a literature review. United Nations Industrial Development Organization Staff Working Paper no. 02.

Kefela, Ghirmai T., 2011. The impact of mobile phone and economic growth in developing countries. *African Journal of Business Management* **5(2)**, 269-275.

Khordagui, Nagwa Hosny, and Gehan Saleh, 2013. FDI and Absorptive Capacity in Emerging Economies. *Topics in Middle Eastern and African Economies* **15(1)**, 141-172.

Kilishi, A. A., H. I. Mobolaji, M. A. Yaru, and A. T. Yakubu, 2013. Institutions and Economic Performance in Sub-Saharan Africa: A Dynamic Panel Data Analysis. *Journal of African Development* **15(2)**, 91-120.

Le, Hoi Quoc, 2008. The Theories of Trade, FDI and Technology Transfer: A Survey. DEPOCEN Working Paper no. 2008/13.

Looy, J. van de, and L.J. de Haan, 2006. Africa and China: A Strategic Partnership? *Strategic Analysis* **30(3)**, 562-575.

Lucas, Robert E., 1988. On the Mechanics of Economic Development. *Journal of Monetary Economics* **22**, 3-42.

Mankiw, N. Gregory, David Romer, and David N. Weil, 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics* **107(2)**, 407-437.

Matthew, A. Oluwatoyin, and B. Folasade Adegboye, 2014. Trade Openness, Institutions and Economic Growth in sub-Saharan Africa (SSA). *Developing Country Studies* **4(8)**, 18-30.

Mayer, Joerg, 2001. Technology Diffusion, Human Capital and Economic Growth in Developing Countries. United Nations Conference on Trade and Development Discussion Paper no. 154.

Mercan, Mehmet, Ismet Gocer, Sahin Bulut, and Metin Dam, 2013. The Effect of Openness on Economic Growth for BRIC-T Countries: Panel Data Analysis. *Eurasian Journal of Business and Economics* **6(11)**, 1-14.

Mohan, Giles, and Dinar Kale, 2007. The invisible Hand of South-South globalization: Chinese migrants in Africa. A Report for the Rockefeller Foundation prepared by The Development Policy and Practice Department, The Open University, Milton Keynes, MK7 6AA, UK.

Omoju, Oluwasola, and Olumide Adesanya, 2012. Does trade promote growth in developing countries? Empirical evidence from Nigeria. *International Journal of Development and Sustainability* **1(3)**, 743-753.

Park, Jungsoo, 2010. Projection of Long-Term Total Factor Productivity Growth for 12 Asian Economies. ADB Economics Working Paper no. 227.

Renard, Mary-Francoise, 2011. China's Trade and FDI in Africa. African Development Bank Group Working Paper no. 126.

Rodrik, Dani, Arvind Subramanian, and Francesco Trebbi, 2002. Institutions Rule: The Primary of Institutions over Geography and Integration in Economic Development. IMF Working Paper no. 02/189.

Sachs, Jeffrey D., and Andrew M. Warner, 1997. Sources of Slow Growth in African Economies. *Journal of African Economies* **6(3)**, 335-376.

Söderbom, Møans, and Francis Teal, 2003. Openness and Human Capital as Sources of Productivity Growth: An Empirical Investigation. CSAE Working Paper no. 2003-06.

Solow, Robert M., 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* **70(1)**, 65-94.

Sun, Peng, and Almas Heshmati, 2010. International Trade and its Effects on Economic Growth in China. IZA Discussion Paper no. 5151.

Swan, T. W., 1956. Economic Growth and Capital Accumulation. *Economic Record* **32(2)**, 334-361.

Tralac, 2014. Trade and Law Centre, Africa-China Trade: http://www.tralac.org/resources/our-resources/4795-africa-china-trade.html.

Uchehara, Kieran E., 2009. China-Africa Relations in the 21st Century: Engagement, Compromise and Controversy. *Uluslararası İlişkiler* **6(23)**, 95-111.

Zelleke, Girma, Abdulwahab Sraiheen, and Keshav Gupta, 2013. Human Capital, Productivity and Economic Growth in 31 Sub-Saharan African Countries for the Period 1975-2008. *International Journal of Economics and Finance* **5(10)**, 1-17.