Does China's Trade Expansion Help African Development? - A South-South Trade Model Approach

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Abstract

With the aim to explain the explosive growth of trade between China and Africa, especially the impacts of China's exportation on African countries, a simple South-South trade model is constructed to formulate the idea that for a technologically backward country to improve its production capability, when there exists nontrivial substitution effects, it is better to import from a South country which has superior technology, than from a North country with enormous technological advance. Then the Comtrade panel data are used to assess the impacts of imports from China (in comparison with those from the USA and France) on Sub-Saharan African manufactured exports (as proxies of their production performances). The results confirm the inference drawn from the model.

Keywords: South-South trade, impact of Chinese exportation on Africa, technology spillover effects, intermediate goods, substitution effects.

JEL Classification: C23 F14 O33

1. Introduction

China-Africa trade expansion has been one of the most remarkable events in the development world (Alden et al., 2008, Manji and Marks, 2007, and van Dijk, 2009). Three tables will illustrate this expansion. Table 1 shows that the Chinese imports from Africa and exports to Africa have increased more than 20 and 10 times between 1999 and 2008 (1-10).

Table 1 inserted here

Table 2, based on Comtrade data, presents China's share in the imports of manufactured goods of Sub-Saharan Africa (hereafter SSA, and Sub-Saharan African is also abbreviated to SSA) relative to the USA, France, UK, Germany, and intra-SSA exports. It has significantly increased from 7.3% in 1990 to about 25% in 2005.

Table 2 inserted here

Table 3 gives the shares of the four most important exporters: the USA, France, China and intra-SSA in the imports of seven manufactured goods by SSA. It confirms that the developed countries were main exporters of equipment goods, while China was the main exporter of textile and leather, and its exports of equipment goods had been significantly increasing.

Table 3 inserted here

In the face of the spectacular development of China-Africa trade links, two natural questions are raised: why has this development taken place and what are its impacts on both sides, in particular on Africa? Up to now, the research work on this topic has focused on the second issue and mostly adopted a macroeconomic approach. Even though there exist major regional and sectoral differences (Asche and Schuller, 2008), China's presence in Africa is judged positive in terms of the impacts on balance of payments, saving, growth rate, investment, and government budget (OECD, 2006, Broadman, 2007). According to OECD (2002), between 1950 and 2000, as one of the world's most open regions, Africa's share of world GDP, measured in terms of PPP, fell by a third, that of exportation by two third, and that of FDI from 6% to 1%. This downward trend can be largely explained by the changes in the terms of trade. Since the mid-1990s, however, most African countries have realized an average growth rate of more than 4%. This growth rate increased steadily between 2000 and 2009. In 2007, it was at a record high of 5.5 percent (OECD 2008). China's trade expansion helps Africa firstly to improve its terms of trade by increasing the demand on African exporting goods, in particular on its natural resource goods, and secondly to reduces its internal inflation with cheap Chinese manufacturing goods (OECD, 2006, Alden, 2007).

There are, however, few empirical studies focusing on the Chinese trade impact on African manufacturing sectors. Two directions for the studies of this impact are the direct bilateral trade links between African countries and China, and the indirect impact: the impact of trade competition from China in third-country markets. Several works (World Bank, 2004, Edwards and Jenkins, 2005, Stevens and Kennan, 2006) based on sector-level studies, or on complementarity-index, conclude that, except in few sectors, the importation of Chinese goods by African countries has trivial negative impacts on African local producers and the Chinese exportation has small impacts on African exportation in the third countries. These studies, nevertheless, have been criticized for having too aggregated and hiding some important specific impacts that can be found only with firm-level methodologies. Kaplinsky et al., (2007) mentioned several studies illustrating that a high percentage domestically produced manufactures in such countries as Ghana, South Africa and Ethiopia are being downsized activity or forced into bankruptcy by imports from China.

Especially the studies on the China-Africa trade relationship are lacking in two approaches: theoretical formalization and econometric tests. These approaches are in particular helpful to address the first question raised earlier: why has China-Africa trade expansion taken place? This study seeks to contribute along these lines of work. First of all, a South-South trade model is constructed on the basis of the existing work on technology spillovers. There has been an abundant literature on North-South spillovers (Cf., Findlay, 1978, Krugman, 1979, Dollar, 1986, Grossman and Helpman, 1991). One obvious drawback with North-South spillovers approach is its failure of dealing with the fact that the intensity of knowledge spillover does not necessarily grow as the technology gap enlarges. In general, technology spillovers occur through three channels: (i) imitation, (ii) linkage, and (iii) workers' mobility (Cf., Sawada, 2010). Mainly two arguments have been used to justify the idea that technology spillovers do not necessarily rise with technology gap. One argument is the absorptive capability of the home countries. Glass and Saggi (1998) formulated the idea that the technology gap must be small enough for the home firm to imitate the foreign firm and hence allow spillovers. With the same line of argument, Kokko (1994) used the example of Mexico to show that spillovers are less likely to occur in industries with large technology gaps and high foreign shares. The second approach is to allow the working of the substitution effects (the imports substitute for local production). Stokey (1988) formally treated the fact that when new products are introduced, a continuous stream of old goods is dropped out of production. Young (1993) treated this substitution and complementarity with a Dixit-Stiglitz production function. Xie (1999) continued this line of thought and constructed a trade model to illustrate that mainly due to the substitution effects the benefit of learning from the more developed country can be realized in the less developed country only when the technology gap is within a certain range. In this paper, I use a simplified model to approach the South-South trade by exploring substitution effects and illustrate the conditions on which for a backward South country (like an African country) to catch up with advanced countries by importation of intermediate goods, it is better to import from modestly superior South country (like China), rather than from a highly developed country.[1] This South-South trade model provides one explanation about increasing China-Africa linkage.

Then on the basis of Comtrade data, an econometric measurement of the impacts of imports from China on SSA countries' manufactured exports will be performed. It is worth mentioning that SSA countries' manufactured exports here are just considered as proxies of their production performances. In other words via measuring the impact of Chinese manufactured exports on SSA's exports, I intend to measure the impact of Chinese manufactured exports on SSA's manufacturing activities. But why do not I directly use manufacturing production data to measure this impact? It is because while SSA's manufacturing production data by country, year and sector suffer from severe deficiency, Comtrade data are, however, very complete. Another question is also important: to what extent do SSA countries' exports reflect their production performances? It will be answered later with empirical tests in Table 5. In comparison with the impacts of the imports from USA and France, I seek to provide evidence that imports from China exert stronger positive impact on SSA. [2]

This paper is organized as follows. Section 2 introduces the model of South-South trade. The section 3, before the conclusion, presents the methodology for econometric modeling, then performs the tests, and finally analyzes the results.

2. A Simple Model of South-South Trade

[1] On the contrary a North-South model being effective implies that for the backward South country, the higher the technology level of its imported intermediate goods, the stronger the spillover effects and the larger the benefits will be.

[2] The UK and Germany are also two of the most important trade partners of SSA. In this paper they are not present in the empirical tests for two reasons: First, the main propose of the paper being to explore China's role in SSA, I am not willing to involve too many countries to give readers the impression that I am doing a comparative study. Second, as I have checked, the econometric tests on them with the same models give rise to results similar to those obtained for the USA and France.

In this section, I adapt a model by Xie (1999), which exposes the trade-off between two effects: 1. Immediate technology spillover effects via importing intermediate goods: Owing to the use of higher technological input, the final products are upgraded in quality, design, and variety without necessarily buying sophistical equipments or changing production process.[3] There are many examples in the real world of this kind of innovation: just by changing one or several components, a product is improved. Blalock and Veloso (2007) have provided a typical case: a shoe producer switches to imported leather because its better malleability allows the creation of more intricate shapes, enabling the production of shoes with greater value added. 2. Sizeable substitution effects of importing intermediate goods on technologically backward countries. This is not trivial to African countries, since they use a number of intermediate goods with quite low technology in their manufacturing sectors. As higher qualified intermediate goods are imported, the traditionally used intermediate goods are more likely to be replaced rather than being complemented. This process of substitution may significantly impact their labor market.

In the followings, I firstly present the model. Then I show the optimal choice of the backward country to trade off the spillover effects and substitution effects with an objective function and the first-order condition with respect to catching-up level. Finally, using this fist-order condition I perform comparative static analysis to show how different parameters shaping the substitution level, the extent of increasing returns of variety, and finally the technological gap affect the choice of the backward country. The final objective is to bring out the boundary condition under which a South-South model, rather than a North-South model becomes effective. In other words, I show up the condition under which it is better to import from a South country with superior technology, than from a North country with enormous technological advance.

There is a technologically backward country A in the face of a country B. B is one in a set of countries with technologies higher than A, but different among them. They produce and consume two final goods: A manufactured goods X_1 and a agriculture goods X_2. X_2 is produced with labor and the unit labor input is one. Denote α as the share of income spent on X_1. X_1 can be produced with different technology k, which makes use of intermediate goods in the range of [$(1-\theta)k$, *k*].

The function of production of X_1 is

[3] A stream of papers has econometrically shown that importing intermediate goods raises productivity via learning, variety or quality effects (cf. Fernandes, 2007, Amiti and Konings, 2007, Kasahara and Rodrigue, 2008).

$$X_{1i} = k_i{}^{\beta} \int_{(1-\theta)k_i}^{k_i} q_\tau \, d\tau \quad \text{(i=A, B;} \beta \geq 1; 0 < \theta < 1) \tag{1}$$

The intermediate goods are ranked from the lowest: (1-θ)$k_1 i$ to the highest: k_i, and it is the range of intermediate goods which determines the technological level of the production. A higher indexed technology is potentially more productive because it employs a wider range of intermediate goods. θk (=$k-(1-\theta)k$) is the number of intermediate goods used in the production of X_1. In equilibrium, all intermediate goods are symmetrically produced. In other words, $q_\tau = q_\tau'$, for $\tau, \tau' \in [(1-\theta)k_i, k_i]$: the quantities of different intermediate inputs are the same. The function of production is assumed to be the same for all intermediate goods: $q_\tau = l_\tau$, one unit of labor is required to produce one unit of intermediate goods. Thus, $\theta k_i q_\tau = \theta k_i l_\tau = \theta k_i l = L_{1i}$. τ is dropped due to symmetry and l is unit labor input for every intermediate goods. Here to simplify, it is also assumed that all labor X_1 is used in the production of intermediate goods. No labor is directly involved in the production of final goods. Thus equation (1) can be rewritten as

$$X_{1i} = k_i{}^{\beta} L_{1i} = \theta k_i^{\beta+1} l \tag{1A}$$

This is a Dixit-Stiglitz type love-of-variety production function. The assumption $\beta > 1$ captures the increasing returns of variety of intermediate goods in the production.

In the case of autarchy, in equilibrium, for country i, $w_i = p_{2i} = 1$, the real wage in terms of X_1 is $k_i{}^{\beta}$, and $p_{1i} = \frac{1}{k_i{}^{\beta}}$. $L_{1i} = \alpha L_i$, and $L_{2i} = (1-\alpha)L_i$ (c.f. Helpman and Krugman 1985, chapter 3). The development level of the country is determined by k , the higher k is, the higher its technological level and also its real wage.

In the case of trade, to simplify my analysis, I present the objective function of country A as a revenue function or GDP function: $R_A = Q_{x1} + p_{x2}Q_{x2}$ where p_{x1} is treated as numeraire (c.f. Helpman and Krugman 1985, chapter 2). Figure 1 helps us to define the net gain of R_A (i.e., the revenue generated after the use of the imports of manufactured intermediate goods minus the revenue in the case of autarchy) and illustrate the technology enhancement and substitution effects by importation of intermediate goods implied by the production function of X_1.

Figure 1 inserted here.

In Figure 1, without trade, country A uses a technology of rank k_A and a rang $k_A - (1-\theta)k_A = \theta k_A$ of own produced intermediate goods, and its labor employed in X_1 sector is $L_{1A} = \theta k_A l$ (B+C in Figure 1). Country B uses a technology of rank k_B and a rang θk_B of own produced intermediate goods, and its labor employed in X_1 sector is $L_{1B} = \theta k_B l$ (A+B in Figure 1). $\Delta k (= k_B - k_A)$ being the technology gap between two countries, if country A adopts country B's technology by importing from B a range of Δk of intermediate goods, its technology rank will enhance to k_B. But meanwhile due to substitution effects, a share of $(1-\theta)\Delta k$ of the local production of intermediate goods will be replaced, and hence a share of $(1-\theta)\Delta kl$ (C in Figure 1) of labor working in X_1 sector will lose their jobs and probably convert to the production of X_2. θ shapes the substitution effects. The higher the $(1-\theta)$, the higher the substitution level.

The task for country A is to choose among a set of countries having higher but different technologies with which A engages in trade. To express in another way, country A should choose the optimal technology gap Δk^* which maximizes its gain. From the equation (1A) and with the help of Figure 1, we know that through technology improvement by importing a range of Δk of intermediate goods, country A's production of X_1 rises by $[\theta k_A - (1-\theta)\Delta k]{k_B}^{\beta} l - \theta {k_A}^{\beta+1} l$). Note that $[\theta k_A - (1-\theta)\Delta k]l$ corresponds to the distance B in Figure 1. By substitution, $(1-\theta)\Delta kl$ (C in Figure 1) of labor in X_1 sector will be replaced. Assuming this share of labor going to X_2 sector, the production of X_2 will rise by $(1-\theta)\Delta kl$.[4]

Thus for country A, its net gain is

$$\pi_A = [\theta k_A - (1-\theta)\Delta k](k_A + \Delta k)^{\beta} l - \theta {k_A}^{\beta+1} l + p_{x2}(1-\theta)\Delta kl \qquad (2)$$

By deriving, the first-order condition with respect to Δk is obtained.

$$\frac{\partial \pi_A}{\partial \Delta k} = (k_A + \Delta k)^{\beta}\left[\beta\left(\frac{k_A}{k_A + \Delta k}\right) - (\beta+1)(1-\theta)\right] + p_{x2}(1-\theta) = 0 \qquad (3)$$

Equation (3) establishes the optimal condition for the catching-up level. Totally differentiating (3) with respect to Δk and k_A, and by rearrangements, one gets

$$\frac{\partial \Delta k}{\partial k_A} = 1 - \frac{1}{(\beta+1)(1-\theta) - \frac{(\beta-1)k_A}{k_B}} \qquad (4)$$

The equation (4) is the final result I intend to derive. Its importance resides in its ability to define the boundary conditions that distinguish the North-South model from the South-South model.

[4] In Figure 1, the distance A (= Δkl) corresponds to country B's labor used for the production of intermediate goods exported to country A. These imported intermediate goods produce a quantity $\Delta kl k_B^{\beta}$ of X_1. I exclude this share of production from country A's net gain by assuming that it is the "price" country A pays to country B for importing higher ranked intermediate goods. This is the minimum price since country B using the same quantity of intermediate goods would produce the same quantity of X_1.

When $\frac{\partial \Delta k}{\partial k_A} < 0$, it signifies that the lower the importing country's initial technology level, the higher the new technology level it can adopt through importing intermediate goods. This is a typical North-South model. On the contrary, $\frac{\partial \Delta k}{\partial k_A} > 0$ means that a technologically backward country has to aim at partial catching-up effects rather than full catching-up effects by importing the modestly superior rather than highly advanced technology. In other words, a more backward country has to fill smaller technology gap than a less backward country. In this case, the model becomes a South-South trade model. The equation (4) allows us to check on what conditions this ratio becomes positive or negative. It defines the boundary condition which distinguishes a South-South model from a South-North model.

Recall that $(1-\theta)$ measures the substitution level. A first examination of the equation (4) now makes clear that when $(1-\theta)$ falls to a certain level, $\partial \Delta k / \partial k_A < 0$ and North-South model becomes effective. Inductively, when substitution effects are trivial, all backward countries have interest in importing highest technology.

To measure the impact of substitution level on importing countries with different technology gaps under different levels of increasing returns, we present the simulation results on the basis of Equation (4) in Table 4. In this table, the numerical values are calculated boundary values of ($1-\theta$) under which North-South model becomes effective and above which South-South model becomes effective.

Table 4 inserted here.

Firstly, as lower boundary value of ($1-\theta$) signifies a tighter constraint for backward countries to catch up, the simulation results reveal that the very backward countries are much more seriously constrained by substitution effects, whereas moderately backward countries are less constrained to adopt North-South model. k_A / k_B fixes the range of technology gap between the importing and exporting countries in the equation (4), and a lower value of k_A / k_B corresponds to a larger range between the lowest and the highest technologies. For instance, when $k_A / k_B = 0.3$, and $\beta = 5$, all substitution levels higher than 0.367 lead to $\partial \Delta k / \partial k_A > 0$, whereas when $k_A / k_B = 0.7$, and $\beta = 5$, just all substitution levels higher than 0.633 lead to $\partial \Delta k / \partial k_A > 0$. As Figure 1 has illustrated, the parts A, B, C are all function of the technology gap. The larger the technology gap (the larger the part A) is, the larger the part C (the replaced employment in X_1 sector) and the smaller the part B (the kept employment in X_1 sector). In generally in a world of high inequality in terms of technology gap, the South-South model seems more likely to be effective since this high inequality make the very backward countries much more seriously constrained by substitution effects.

Secondly, Table 4 shows that in general, the boundary values of $(1-\theta)$ fall as β increases in the case of low values of k_A/k_B (<0.5) and the boundary values rise as β increases in the case of high values of k_A/k_B (>0.5). The result for the first case means that the higher the increasing returns of variety, the more tightly the backward countries are constraints by substitution effects and hence they are more likely to adopt South-South model. This appears counter-intuitive if reasoning that with higher increasing returns, one could expect less serious constraints imposed by substitution effects. The explanation is that β reflecting increasing returns shapes at once the benefits from adapting the new technology and the losses due to substitution. From the equation (2) we observe that β amplifies at once the gains from importing new technology and the losses due to substitution. For a country with very low k_A, the rise of β intensifies so sharply the losses that it has to adopt South-South model at lower boundary value of $(1-\theta)$. This tendency is manifested in mathematical way in the equation (4). Set the equation (4)=0, one gets $(1-\theta)=\frac{1}{\beta+1}+\frac{(\beta-1)}{(\beta+1)}\frac{k_A}{k_B}$, and when $\frac{k_A}{k_B}<0.5$, the increase of β induces large fall of the first term than the rise of the second term on the right of the equation, thus $(1-\theta)$ falls.[5]

3. **Estimating the Impact of Chinese Exportation on SSA**

In the last section I have used a model to show that for a technologically backward developing country to improve its production capability through the trade-off between the benefits of technology spillovers and the costs of substitution effects, it is better to import from a South country with a superior technology than from a North country with a very advanced technology.

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[5] When $\frac{k_A}{k_B}=0.5$, with the change of β, the fall of the first term always equals the rise of the second term, resulting $(1-\theta)$ constant.

Empirical inference will be that the importation of Chinese manufactured intermediate goods must be more helpful to African manufacture development than their importation of this kind of goods from most developed countries. The most direct way to test this thesis is to regress African countries' manufactured productions on their importations of manufactured intermediate goods from China in comparison with their importations of these goods from some developed countries. But the data on African countries' manufacturing by sector and country are seriously incomplete. Given that Africa is the second most opened region after Asia in terms of the ratio of trade volume to GDP, African countries' exportation is a good indicator for their production development. The impacts of their imports on their exports can be, to a large extent, interpreted as the impacts on their production. In other words, SSA countries' exports are used here as proxies of their manufacturing performances.

To verify the assumption that African exportation is highly correlated with production, with the UNIDO industrial statistics database of 28 industrial sectors and of 17 SSA countries from 1976 to 2004, the following regression results are obtained:

Table 5 inserted here

Whenever the OLS, fixed-effects model or random-effects model are used, African industrial value added is significant to explain both their exportation and importation.

To put up my econometric tests, from Comtrade, the cross-importation and exportation data of 7 manufactured products (1, textiles and clothing; 2, leather, rubber, and footwear; 3, chemicals; 4, transport equipment; 5, non-electric machinery; 6, electric machinery; 7, miscellaneous manufactured articles) of 86 countries (including 47 of SSA, 12 of Asia, 15 of Europe, 2 of North America, and 10 of Pacific region) from 1988 to 2005 are gathered, and all major trade partners of SSA countries are included.

These Comtrade data contain the reporting values of cross-importation and exportation by country, sector and year. A problem arising from these data is that often the reported values of exportation and importation by two partners diverge and there exist omissions. The following rules are applied to deal with this problem: 1. For the trade between an African and a non-African country, the "mirror method" is used: i.e., the reporting value of the non-African country is chosen, but the reporting values of the African country is chosen if the non-African country's reporting values is missing; 2. For the trade between two African countries, the higher value reported by one of the two partners is chosen.

Before the regressions tests, the presentation of some descriptive information on SSA's import and export structures of manufactured goods is of interest, since it gives us an idea about the relative importance of the variables chosen in the econometric models. Tables 6 and 7 are obtained from the data of 86 countries.

Table 6 inserted here

From Table 6, the most important feature of the SSA's structure of exports is the rising shares of transport equipment and non-electric machinery. The textile is decreasing, and chemical unstable but significant in share.

Table 7 inserted here

Table 7 shows that SSA's imports are overwhelmingly composed of equipments and chemical goods. Textile goods imports represent around 10% and tend to increase.

It is noteworthy that Table 3 about the shares of the major partners in the imports of seven manufactured goods by SSA is informative to give reason for the choice of the exports of the three countries: the USA, France and China as regressors, since in these sectors and during the chosen periods they are all significant export partners with SSA.

Finally, I provide Table 8 to show the evolution of the destinations of SSA's exports. It may be informative to clear up a doubt about the regression results: if Chinese manufactured exports positively impact SSA manufactured exports, it could be that the increase in China's exports to SSA is associated with reductions in trade barriers in both directions, as a result, exports from SSA to China increased as well. As shown in Table 8, SSA's manufactured exports to China have held an insignificant share during the period that will be chosen for my tests.

Table 8 inserted here

a. Methods of Estimation

One general approach to take into consideration for testing the above theoretical model is to regress SSA countries' exports by products and year on their imports from, e.g., China by products and year. Nonetheless, to deal with the "naive" aspect of this approach, three problems must be solved: 1, the errors of measurement bias; 2, multicollinearity of the explanatory variables, and 3, endogeneity.

Firstly, consider the errors of measurement bias. As we know, the import of a certain product from a certain country will exert impacts on all sectors of the importing country that either produce the same product or use it as input. A "perfect" estimation is possible only when for every importing country we have perfect information on the distribution of the imports of, e.g., Chinese textile products between final consumption and inputs needed in the production process on the one hand, and the distribution of the inputs among different productive sectors on the other hand. In this case, and other things equal, we are able to measure, with the quantitatively precise explanatory variables, the impacts of the imports of Chinese textiles on SSA's textile as well as on all other sectors that also use Chinese textile goods as input. Unfortunately, we lack this information, and are only able to approximately estimate these impacts. We want these approximations being as close as possible to the true impacts.

When we regress, e.g., SSA's exports of footwear by exporting country on their total imports of Chinese textile goods, there are errors of measurement bias in that one part of these imports is destined to consumption and to other sectors as input. This is a typical problem of "errors of measurement bias in the explanatory variable" (Gujarati, 2004, 526-528). Denoting, for a certain SSA importing country, *x** the part of imports of Chinese textile goods used as input by a certain sector (e.g. footwear), instead of knowing x*, we only know *x*, the total quantity of imports of textiles goods from China, with *x*=*x**+*w*. In this case, perform a regression with the equation: $y_i = \alpha + \beta x_i^* + u_i = \alpha + \beta x_i - \beta w_i + u_i$, where y is the export of the footwear sector by SSA country i. Even *w* is assumed having zero mean, being serially independent, and uncorrelated with u_i, one can no longer assume that the composite error term $(u_1 i - \beta w_1 i)$ is independent of the explanatory variable *x*, thereby the estimates tending to be not only biased but also inconsistent. It can be proven that the magnitude of the bias depends on $\sigma^2_{w_i} / \sigma^2_{x_i^*}$. In other words, the bias is restricted if w_i is enough small relating to x_i^*.

The chosen method to constrain w_i is to regress the exports of a certain product on the imports of the same product. In other words, one regresses, e.g., the SSA countries' exports of textile on their imports of Chinese textile goods, but not the SSA countries' exports of footwear on their imports of Chinese textile goods, even though these impacts are known existing since textile goods is an important input for footwear sector. In a manner in which only the impacts of intra-sector imports, but not inter-sector imports are measured., the w_i is limited, since, if referring to input-output tables, in general for most manufactured goods, a larger than half of the production is used for final consumption, and in the rest employed as input, the own sector is always the largest user.

As intra-sector regressions are performed, given that the theoretical model has just incorporated the net impact of imported intermediate goods (that is the positive technology spillover effects less substitution effects on local producers of intermediate goods) while the empirical results contain another obviously existing effects: the substitution or crowding-out effects on local producers when imports are used as consumption goods (the more consumption goods are imported, the less the demand for local production is). Denote T1 as empirically estimated impact including negative substitution effects on local production of consuming goods and T2 the impact identified by the model, then T1-T2=S, where S is substitution effects of imports of consumption goods with negative sign. In the case of intra-sector regressions, three possible empirically estimated impacts on SSA's exports are: 1, as an explanatory variable, imports from a foreign country is not significant; 2, it is significantly negative; 3, it is significantly positive. First result implies that the substitution effects go with technology spillover effects, and they balance out. The second result indicates that the substitution effects outweigh the technology spillover effects. Finally, the third result allows us to unambiguously affirm that the technology spillover effects prevail over local production substitution effects. Since T2>T1, as T1 is positive, T2 is also positive and stronger. Thus only when one gets the third result it can be certain that the theoretical model is confirmed.

Applying the above inference, two of the seven manufactured goods must be dropped from the tests: 1, the electronic goods, because their exports by SSA are negligible (around 5% of the total SSA's exports of manufactured goods); 2, the miscellaneous manufactured articles, since they are traditionally artisanal and thus, according to most available input-output tables of these countries, have weak dependence on inputs of imported own sector products.

The second problem to address is the multicollinearity of the explanatory variables. Since the imports from the USA, France and China are chosen to test their impacts on SSA countries' exports, for a certain SSA country, its imports of, e.g., textile products from three countries all exert, to different extent, impacts on its exports of textile products. When employing all of them as regressors, there is a high multicollinearity among them since on average, proportional to the size and the richness of a country, its trade increases with all major trade partners. This high multicollinearity makes precise estimation difficult, the t ratio of one or more coefficients statistically insignificant, and the R^2 unusually high. With some or all of the explanatory variables so highly collinear, one cannot isolate their individual influence on the dependent variable. One solution will be to separately test the impacts of these explanatory variables. The justification for this choice is that the imports from these trade partners, although collinear, meet different demands from consumers of different income levels and of different sectors. The imports from e.g., developed countries mostly satisfy the demands of rich consumers and of capital-intensive sectors. Since these imports from different countries are rarely mutually dependent, and respond to different demands, their impacts on the exports of the SSA country must be distinct.

The third concern is about how to handle the problems of endogeneity and simultaneity. Consider the following panel econometric equation that can be applied to each of the five chosen manufactured products:

$$A_{it} = \alpha + \beta_1 B_{cit} + \beta_2 C_{it} + \delta_i + \varepsilon_{it} \quad (5)$$

i is one of the 47 SSA countries, c is China (or the USA, or France). t is the time period. A reflects the export value of country i of the product at t year. B reflects Chinese export value of this product to SSA country i at t year. C represents the other chosen variables that influence A, δ_i is country i's fixed-effects to control for time-invariant factors that affect i's exportation of this product, and finally, ε_{it} is the error term reflecting other no identified influences on country i's exportation of this product at t year.

The endogeneity problem here is that the exogenous variable B correlates and often depends on ε. Another important form of endogeneity is simultaneity. This problem is posed when one or more explanatory variables are jointly determined with the dependent variable. This is likely the case for SSA countries' exports and their imports from China. Therefore, just using real values of imports from China to estimate their impacts on SSA countries' exports may be misleading given that in the presence of endogeneity, the estimates with OLS method are seriously biased. The instrumental variable (hereafter IV) technique is designed explicitly to handle the problem of this kind, that is, to find one or several IVs that are correlated with B, but uncorrelated with the error term. With these IVs one estimates the constructed B, and then puts this constructed B into the econometric equation to measure the unbiased impacts.

A generally served method is the building of a gravity model consisting of using some geographical variables of the trade partners to predict the trade volumes between them.[6] The following equation is used to predict all SSA countries' imports by manufactured product and year from other countries:

$$M_{ijt} = \alpha_{it} + \beta_1 Y_{it} + \beta_2 Y_{jt} + \beta_3 D_{ij} + \beta_4 P_{it} + \beta_5 P_{jt} + \beta_6 Z_{ij} + \beta_7 T + \varepsilon_{it} \quad (6)$$

M is the importation value in constant price of SSA country i from country j at t year (j is one of the 86 countries and can be either SSA or non-SSA countries), Y, D and P are the GDP, distance, population. Z represents dummy variables (including four: if the importing country is

[6] Cf., Frankel and Romer (1999), one widely cited work on the application of a gravity model.

landlocked; if the two trade partners have historically colonial relationship; if the two countries have the same official language, and if there is contiguity between importing and exporting countries). Finally, T is a time trend variable. The data on geographic variables come from CEPII (http://www.cepii.fr/distance/). The data on GDP and population come from the *World Bank Indicators*.

All parameters of the five manufactured products are individually estimated and then the importation of each SSA country by year and exporting country is predicted. Random-effects model is chosen due to the existence of time invariant variables. The group variable is the importing country. With this technique, corresponding to real trade values (ended by _real), the simulating results (ended by _pred) of the exports of 86 countries to SSA by sector and year are obtained. The descriptive statistics of the data of the period 1988-2005 are presented in Table 9.[7]

Table 9 inserted here

Table 10 presents the regression of pooled real trade values on the predicted trade values by gravity model (by importing country, exporting country, product and year). Both tables 9 and 10 show that the predicted results are quite satisfactory.

Table 10 inserted here

After having made all these preparations, the panel regressions for each of the five chosen manufactured products are performed with the specifications of the following equation:

$$lnEXP_{it} = \alpha + \beta_1 \ln IMP_{ikt} + \beta_2 \ln POPU_{it} + \beta_3 \mathbf{per}_{\mathbf{INDU}_{90_i}} + \delta_i + \varepsilon_{ikt} \quad (7)$$

i is one of the 47 SSA countries, k is one of the three countries from which SSA countries import, i.e., the USA, France, and China, t is the time period, δi reflects a country fixed-effects to control for time-invariant factors that affects country i's exportation, and finally ε, the error term reflects other no identified influence on country i's exportation of that manufactured product by k at t year. In these regressions, two control variables are used: 1. Ln_popu is the exporting SSA country's population in logarithm form to control country-size effect. 2. per_indu_90 controlling industrial capability effect is industrial production of each exporting SSA country of 1990 divided

[7] The data anterior to 1990 containing many zero trade values are only used in gravity models, and the sample for my final regression tests starts from 1990. The panel is unbalanced since some SSA countries did not import or export some manufactured goods in some years.

by its urban population in that year, since it seems reasonable to assume that manufactures are mainly activities of urban people.[8] All monetary values are in constant price.

The random-effects model rather than the fixed-effects model is employed since per_indu_90 is a time invariant variable. Another reason for using the random-effects model is that with IV method on the basis of the gravity model, we have corrected the endogeneity and thus can be less worried about the violation of the crucial assumption of the random-effects model that the error term is uncorrelated with the regressors.

b. Analysis of the Results

Both the results of random-effects model and Generalized two-stage least squares random-effects IV (hereafter G2SLS-RE-IV) model are shown from Table 11 to Table 15. In general the estimates of the first model are biased and just served as references. In both models robust estimators are used to avoid the conditionally heteroskedastic errors. T statistics on the basis of bootstrap standard errors (for random-effects model) and z statistics (for G2SLS-RE-IV) are in parentheses. In G2SLS-RE-IV, IVs are the corresponding variables predicted by gravity model (the predicted imports from the USA, France, and China by sector, SSA country and year).

The most important finding is that according to G2SLS-RE-IV estimations for all regressions of SSA countries' exports of five products, the impacts of imports from China are significantly positive. As explained in the theoretical model, if the spillover effects outweigh the local production substitution effects, the overall impact tends to be positive.

Next, in most sectors, the impacts of imports from the USA and from France are insignificant except imports of chemical goods from the USA and imports of transport equipment from France. To explain these exceptions, it is quite possible that in certain cases technology spillover effects of the imports of intermediate goods from developed countries become strong, thereby leading to overall positive impact. Chemical sector may be the case since in which the developed countries, in particular the USA, dominate China and most emerging industrial countries.[9] Also, the French eminent position in transport equipment sector in Africa, especially in Western Africa can explain the above French impact.

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[8] In order to keep away from the obstacle of simultaneity that could make the results invalid, I consider the industrial capabilities of SSA countries of each year in the sample as accumulated extensions of the baseline.

[9] It is well known and can be verified in every China Economic Yearbook since 1978 that even China imports a major share of chemical goods from developed countries. Until now, among the manufactured

One similarity of results in this study with those of Frankel and Romer (1999) is that in general with IVs generated by gravity model, the estimated impacts are markedly stronger than using ordinary model without correcting endogeneity by IVs, implying that ordinary model underestimates the impacts. In the case of textile, the coefficients of imports from China increase from about 0.2 to 0.9, indicating that one percent of increase of imports from China leads to 0.9 percent of increase of textile export. This elasticity for leather, chemical, transport equipment and non-electrical machinery are respectively 0.7, 1.2, 0.7 and 0.7, all visibly higher than those obtained by ordinary random-effects model. In the case of the USA and of France, the same trend is observed.

The fact that ln_af_popu and per_indu_90 are not significant in most G2SLS-RE-IV regressions seems to mean that among the SSA countries, it is not necessarily the larger countries (in terms of population) and (or) those with a higher industrial level that export more manufactured goods, and that SSA countries' exports of manufactured goods are deeply linked with agriculture and traditional artisanal skills. African industrial capability may be more adequate to explain their development in the exploitation of mines rather than in manufactures.

Wald Chi2 values are quite high. The values of R^2 are all fairly satisfactory. The rho value is between 0.7 and 0.9, signifying that the individual effects of SSA exporting countries are strong. The sample size is in general smaller in G2SLS-RE-IV regressions than in RE, because some negative predicted import values converted in logarithm form become missing values.

Table 11 inserted here

Table 12 inserted here

Table 13 inserted here

Table 14 inserted here

Table 15 inserted here

There may be a following query regarding the above results: do these results merely reflect the re-exportation phenomenon, i.e. by re-exportation, those SSA countries that import more Chinese goods also export more? We cannot categorically reject the possibility that to some extent

goods, the chemical, plastic and rubber, optical, photographic, measuring, checking, precision, medical or surgical instruments and apparatus are the items on which China's trade balance shows a heavy deficit.

re-exportation plays a role, given that Sub-Saharan Africa is a region in which intra-regional migration is much freer than most other regions in the world, and historically the countries in this region are "separated by arbitrarily drawn boundaries that sometimes cut across homelands of ethnic or language groups" (Adepoju, 2006), and hence border trade is important. Nevertheless, in Comtrade data, re-exportation among countries is independently accounted and has been precluded from our samples. Unless the errors of measurement in Comtrade data are serious (about this, we have no information), we cannot affirm that re-exportation plays a strong role.

Finally, seeing that South Africa has a large share in SSA's exports of manufactured goods, as robust tests of the results, I remove the exports of the South Africa from the above regressions and found that the results (not shown here) are nearly the same in terms of the signs and the significance of the explaining variables.

Conclusion

The objective of this work is to explain the explosive growth of trade between China and Africa, in particular the impacts of China's exportation on African countries. At the first stage, with the construction of a South-South model, I formally expressed the idea that when non trivial substitution effects are present, for a technologically backward developing country to improve its production capability, it is better to import from a South country with a superior technology than from a North country with a very advanced technology.

Then at the second stage, using Comtrade data of 86 countries covering five manufactured goods and the period 1988-2005, and a gravity model to treat endogeneity problem, I estimated impacts of the imports from the USA, France and China on SSA countries' exports by sector and year (as proxies of their manufacturing production performances). It was found that in general the imports from China had significant positive impacts on SSA countries' exports of manufactured goods, while those of the USA and of France exerted positive impacts only on very few products of which most emerging countries including China have weak supply capability. Therefore the empirical tests confirm the inference drawn from the theoretical model.

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Table 1 China's trade with Africa (in million USD)

	Importation	Variation (in %)	Exportation	Variation (in %)
1999	2375	-	4115	-
2000	5555	+ 133.9	5042	+ 22.5
2001	4793	- 13.7	6007	+ 19.1
2002	5427	+ 13.2	6961	+ 15.9
2003	8360	+ 54.0	10182	+ 46.3
2004	15646	+ 87.2	13816	+ 35.7
2005	21063	+ 34.6	18683	+ 35.2
2006	28770	+36.6	26690	+42.9
2007	36283	+ 26.1%	37028	+ 38.7%
2008 (1-10)	50494	+76%	42211	+42%

Note : Source: http://www.mofcom.gov.cn

Table 2 The shares of six principal exporting partners in the imports of manufactured goods by SSA

Year	China	USA	France	UK	Germany	Intra-SSA
1995	7.3%	18.2%	26.3%	19.8%	24.2%	4.1%
2000	11.1%	15.9%	22.9%	12.9%	17.7%	19.5%
2005	24.6%	16.1%	16.2%	11.6%	22.0%	9.4%

Note: On the basis of Comtrade data used in this study, with the total imports from the six partners as 100%.

Table 3 The SSA's import structure of manufactured goods by export origin (in %)

	USA			France			China			Intra-SSA		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Textiles & clothing	16.3%	6.5%	3.2%	18.7%	8.4%	4.2%	51.8%	52.5%	83.5%	13.3%	32.5%	9.2%
Leather, rubber, footwear	13.8%	8.2%	6.3%	25%	12.7%	8.2%	49.8%	38.2%	68.9%	11.5%	41%	16.6%
Chemicals	30.9%	19.5%	18.2%	49.1%	32.9%	37.3%	5.7%	7.5%	19%	14.3%	40.2%	25.5%
Transport equipment	27.7%	26.1%	39.2%	62%	48.5%	25.9%	5.9%	6.8%	20.5%	4.4%	18.5%	14.5%
Non-electric machinery	48.7%	37.2%	39.2%	43.5%	31.4%	27.3%	4.5%	8.3%	22.6%	3.3%	23.1%	11%
Electric machinery	25.5%	16.4%	13.3%	54.7%	38.9%	30.2%	14.4%	21%	27.8%	5.4%	23.7%	8.8%
Miscellaneous manufactured articles	42.1%	25.8%	25.8%	41.3%	21.2%	21.1%	11.2%	14.8%	34.8%	5.5%	38.2%	18.3%

Note: On the basis of Comtrade data used in this study, with the total imports from the four partners as 100%.

Figure 1 Technology enhancement and substitution effects of importation of intermediate goods implied by the production function of X_1

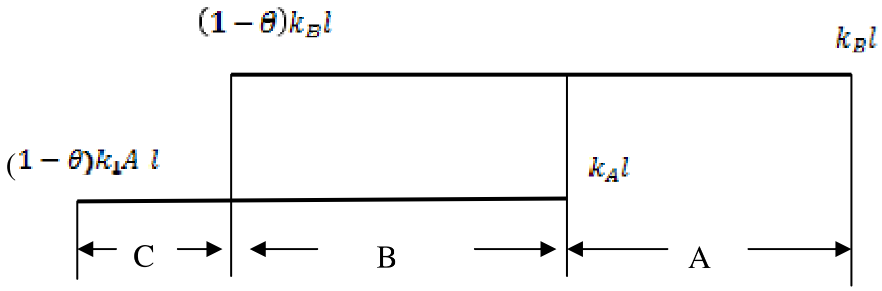

Table 4 Simulation results: boundary values of ($1-\theta$) on the basis of the equation (4)

	$\beta = 2$	$\beta = 3$	$\beta = 4$	$\beta = 5$	$\beta = 6$	$\beta = 7$	$\beta = 8$	$\beta = 9$	$\beta = 10$	$\beta = 20$
$k_A/k_B = 0.3$	0.433	0.4	0.38	0.367	0.357	0.35	0.344	0.34	0.336	0.319
$k_A/k_B = 0.5$	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
$k_A/k_B = 0.7$	0.567	0.6	0.62	0.633	0.643	0.65	0.656	0.66	0.664	0.681

Table 5 Regressions of exports and imports (total value) on industrial added-values by SSA country, sector and year

	(1)ols	(2)fe	(3)re	(4)ols	(5)fe	(6)re
	exp_tv	exp_tv	exp_tv	imp_tv	imp_tv	imp_tv
Industrial_av.	0.386	0.395	0.393	0.603	0.548	0.557
	(39.49)***	(32.31)***	(32.80)***	(37.89)***	(27.67)***	(28.92)***
Constant	12,831.250	11,773.423	7,471.401	71,661.296	78,571.243	68,656.301
	(4.30)***	(3.81)***	(0.78)	(14.77)***	(15.67)***	(5.35)***
Observations	4459	4459	4459	4459	4459	4459

Note: t statistics (for ols and fixed-effects regressions) and of z statistics (for random-effects regression) are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The group variable is SSA countries.

Table 6 The SSA's export structure of manufactured goods

	1995	2000	2005
SSA to the world	Textile 36.7%	Textile 27.29%	Transp. Equip. 28.84%
	Leather 16.38%	Transp. Equip. 20.26%	Non-electric 20.33%
	Chemical 16.18%	Non-electric 18.85%	Textile 19.44%
	Non-electric 11.21%	Chemical 10.13%	Chemical 13.49%

Note: The total exports of the seven manufactured products as 100%.

Table 7 The SSA's import structure of manufactured goods

	textile	Leather	Chemical	Transp. equip.	Non-electric	Electric	Miscellaneous manufactured articles
1995	7.73%	2.97%	18.77%	21.94%	27.99%	13.41%	7.18%
2000	9.65%	3.26%	18.35%	26.30%	22.07%	13.44%	6.92%
2005	11.09%	3.36%	15.53%	24.19%	24.73%	14.59%	6.52%

Note: The total imports of the seven manufactured products as 100%.

Table 8 – the shares of main importers of manufactured goods from SSA (in %)

	2000	2001	2002	2003	2004	2005
China	1.9	2.2	1.6	2.3	2.6	2.6
EU (15)	72.0	69.4	68.4	66.1	66.2	69.9
- France	12.7	12.3	12.5	12.0	11.1	10.6
- U.K.	15.2	14.6	16.8	14.9	15.0	14.5
- Germany	20.1	21.3	20.0	19.1	16.1	16.7
The USA	26.1	28.4	30.0	31.7	31.2	27.4

Note: Calculated on the basis of Comtrade Data.

Table 9 Descriptive statistics of the real and predicted trade values (1988-2005)

Variable |	Obs	Mean	Std. Dev.	Min	Max
Trade_value_real	118317	4660843	3.73e+07	0	2.57e+09
Trade_value_pred	115864	4755266	1.47e+07	-1.90e+07	1.69e+08

Table 10 Regression of pooled real trade values on predicted values (1988-2005)

	tradevalue_real
trade_value_pred	1.030
	(149.73)***
Constant	-142774.1
	(-1.34)
Observations	115862
Adj. R-squared	0.1621

Note: t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The group variable is SSA countries.

Table 11 Regressions of exports of SSA countries on imports from three countries (textile)

	(1) RE	(2) G2SLS- RE-IV	(3) RE	(4) G2SLS- RE- IV	(5) RE	(6) G2SLS- RE-IV
	ln_textile	ln_textile	ln_textile	ln_textile	ln_textile	ln_textile
ln_af_popu	2.075	5.904	1.173	1.258	1.207	0.037
	(4.40)***	(0.27)	(4.44)***	(1.69)*	(4.97)***	(0.16)
per_indu_90	0.002	0.003	0.001	0.001	0.001	0.001
	(2.11)**	(0.44)	(2.56)**	(0.69)	(2.42)**	(1.81)*
ln_usa_textile	0.064	-4.050				
	(1.09)	(0.17)				
ln_fra_textile			0.094	-0.581		
			(1.39)	(0.17)		
ln_chn_textile					0.195	0.887
					(3.28)***	(4.95)***
Constant	-19.490	-23.662	-5.410	2.361	-7.720	0.616
	(2.76)***	(0.33)	(1.17)	(0.06)	(2.15)**	(0.23)
Observations	592	577	523	457	615	602
R-sq	0.2245	0.0183	0.2707	0.0662	0.2725	0.3559
Wald chi2	37.09	0.59	24.16	6.77	79.55	57.74
(prob>chi2 in parentheses)	(0.000)	(0.899)	(0.000)	(0.08)	(0.000)	(0.000)

Table 12 Regressions of exports of SSA countries on imports from three countries (leather)

	(1) RE	(2) G2SLS- RE-IV	(3) RE	(4) G2SLS- RE- IV	(5) RE	(6) G2SLS- RE-IV
	ln_leather	ln_leather	ln_leather	ln_leather	ln_leather	ln_leather
ln_af_popu	1.502	-1.204	1.298	1.368	0.967	0.303
	(5.19)***	(0.25)	(6.03)***	(0.27)	(4.21)***	(1.01)
per_indu_90	0.001	-0.000	0.001	0.001	0.001	0.001
	(3.27)***	(0.08)	(4.42)***	(0.04)	(2.70)***	(1.54)
ln_usa_leather	0.022	2.793				
	(0.38)	(0.50)				
ln_fra_leather			0.005	0.107		
			(0.09)	(0.00)		
ln_chn_leather					0.304	0.703
					(5.07)***	(2.73)***
Constant	-10.427	-1.861	-6.805	-9.320	-5.850	-0.747
	(2.26)**	(0.15)	(1.93)*	(0.01)	(1.88)*	(0.31)
Observations	551	547	510	412	594	580
R-sq	0.3098	0.1873	0.3692	0.3890	0.3798	0.3651
Wald chi2	39.03 (0.000)	3.33	43.44	20.89	137.08	59.70
(prob>chi2 in parentheses)		(0.343)	(0.000)	(0.000)	(0.000)	(0.000)

Table 13 Regressions of exports of SSA countries on imports from three countries (chemical)

	(1) RE	(2) G2SLS-RE-IV	(3) RE	(4) G2SLS-RE-IV	(5) RE	(6) G2SLS-RE-IV
	ln_chemical	ln_chemical	ln_chemical	ln_chemical	ln_chemical	ln_chemical
ln_af_popu	0.675	-0.730	0.624	0.370	0.474	-0.442
	(2.99)***	(1.73)*	(2.37)**	(1.23)	(2.32)**	(0.76)
per_indu_90	0.001	-0.000	0.001	0.001	0.001	0.000
	(1.82)*	(0.49)	(1.37)	(1.15)	(1.24)	(0.77)
ln_usa_chemical	0.253	1.644				
	(2.52)**	(4.47)***				
ln_fra_chemical			0.083	0.253		
			(0.88)	(1.12)		
ln_chn_chemical					0.255	1.170
					(2.78)***	(2.38)**
Constant	-1.361	1.785	1.844	3.324	1.909	3.981
	(0.49)	(0.62)	(0.49)	(0.90)	(0.70)	(1.03)
Observations	595	584	530	478	595	581
R-sq	0.2997	0.2868	0.1939	0.1953	0.2462	0.1957
Wald chi2	55.37	70.23	11.81	9.22	37.78	25.03
(prob>chi2 in parentheses)	(0.000)	(0.000)	(0.008)	(0.027)	(0.000)	(0.000)

Table 14 Regressions of exports of SSA countries on imports from three countries (transport equipment)

	(1) RE	(2) G2SLS-RE-IV	(3) RE	(4) G2SLS-RE- IV	(5) RE	(6) G2SLS-RE-IV
	ln_transp	ln_transp	ln_transp	ln_transp	ln_transp	ln_transp
ln_af_popu	0.861	-1.444	0.772	0.418	0.662	-0.193
	(5.70)***	(0.09)	(5.54)***	(2.39)**	(4.21)***	(0.90)
per_indu_90	0.001	-0.001	0.001	0.001	0.001	0.001
	(4.35)***	(0.07)	(3.05)***	(1.32)	(2.86)***	(2.37)**
ln_usa_transp	0.134	2.783				
	(2.49)**	(0.15)				
ln_fra_transp			0.081	0.815		
			(1.21)	(3.20)***		
ln_chn_transp					0.190	0.735
					(3.43)***	(3.67)***
Constant	-2.033	-3.860	0.523	-4.754	0.726	7.013
	(0.94)	(0.12)	(0.20)	(1.10)	(0.31)	(2.30)**
Observations	600	588	534	507	577	421
R-sq	0.2763	0.1042	0.2737	0.2263	0.2693	0.2212
Wald chi2	67.07 (0.000)	0.51	31.26	22.91	45.04	25.04
(prob>chi2 in parentheses)		(0.917)	(0.000)	(0.000)	(0.000)	(0.000)

Table 15 Regressions of exports of SSA countries on imports from three countries (non-electric machinery)

	(1)	(2)	(3)	(4)	(5)	(6)
	RE	G2SLS-RE-IV	RE	G2SLS-RE- IV	RE	G2SLS-RE-IV
	ln_nonelect	ln_nonelect	ln_nonelect	ln_nonelect	ln_nonelect	ln_nonelect
ln_af_popu	0.844	-1.836	0.737	0.470	0.601	-0.133
	(4.56)***	(0.19)	(3.70)***	(1.60)	(3.56)***	(0.57)
per_indu_90	0.001	-0.002	0.001	0.001	0.001	0.001
	(3.77)***	(0.16)	(2.68)***	(2.42)**	(2.90)***	(1.57)
ln_usa_nonelect	0.210	3.375				
	(2.20)**	(0.24)				
ln_fra_nonelect			0.113	0.501		
			(1.23)	(1.48)		
ln_chn_nonelect					0.231	0.724
					(4.55)***	(4.66)***
Constant	-2.607	-7.577	0.723	-1.109	1.371	6.282
	(0.86)	(0.13)	(0.22)	(0.42)	(0.54)	(2.22)**
Observations	624	610	544	518	604	548
R-sq	0.3948	0.2078	0.3497	0.3270	0.4208	0.3627
Wald chi2	43.39	0.26	18.93	40.77	60.12	41.27
(prob>chi2 in parentheses)	(0.000)	(0.967)	(0.000)	(0.000)	(0.000)	(0.000)