# Revisiting the Growth Effects of Sino–African Bilateral Trade on African Economies

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**Abstract**

In this paper, the effect of China-Africa's bilateral trade intensity and concentration, which are alternatively incorporated as threshold variables, on economic growth of African countries, is examined through a non-linear panel threshold approach. Unlike the existing empirical literature on trade-growth nexus for African economies, our findings suggest a heterogeneous trade-growth nexus with the effect of bilateral trade intensity on Africa's economic growth being higher in countries whose trade intensity with China is higher compared to those with lower-intensity. However, although the effect of bilateral trade concentration on Africa's growth has been found for countries whose trade concentration is lower, the growth-effect of trade concentration for countries whose trade concentration is higher is unclear. These results are in contrast to some earlier literature relying on linear-based approaches which mask the parameter heterogeneity and may sometimes lead to inappropriate policy recommendations. Drawn implications emphasize the critical importance of addressing prevailing trade constraints as well as the provision of trade-capacity building for the Chinese market. Combined with the estimated thresholds for trade intensity and concentration, these findings imply four categories of trade policies depending on the position of countries in a trade intensity-concentration matrix.

## 1. Introduction

The influence of the Chinese economy on the rest of the world has become the single most cited development issue in the world, especially in many African countries**.** China has actually increased its contribution to the growth of sub-Saharan African exports, allowing most of sub-Saharan Africa to sustain robust economic growth. By 2014, China was the single largest importer of goods and services from sub-Saharan Africa. Also, access to new markets for Africa's raw materials has spurred its exports, which quintupled in real value over the 20-year period 1995–2015. Perhaps even more importantly, by diversifying its set of trading partners, sub-Saharan Africa has reduced the volatility of its exports. This combination of trading partners helped cushion the impact of the global financial crisis of 2008–09 at a time when Africa's traditional trading partners were experiencing a deep economic contraction that curbed their demand for imports (Maswana, 2010; Chen and Nord, 2017).

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Now that China's economic growth is slowing, and the drivers of its growth are shifting from investment and exports to domestic consumption, this shift is having a particularly large impact on commodity exporters, many of which are in Africa (see Johnston, 2015). After expanding by 5–6 percent over the past two decades, economic growth in sub-Saharan Africa slowed to only 1.5 percent in 2016 (Chen and Nord, 2017). Obviously, through increases in trade linkages, countries' aggregate outputs are increasingly becoming interdependent over time. Naturally, researchers and policymakers have sought to learn more about the growth effects of Sino–African bilateral trade on African economies. Hence, studying economic interdependence, even in terms of econometrics, is useful from a policy perspective.

Most studies on international macroeconomic interdependence have identified a number of variables that can lead to the transmission of a shock from one country to another. For instance, Backus et al. (1992), Bowden and Martin (1995), Baxter and Kouparitsas (2005), and Frankel and Rose (1998), to mention just a few, find evidence in favor of international output synchronization, with trade being the main channel of transmission. Yet in recent years there has been mounting evidence that, rather than trade expansion, it is the composition and concentration of trade flows that matters when it comes to the trade–growth nexus (Hausmann et al., 2005). This means that both trade intensity and trade concentration/diversification determine the resulting effect on economic growth.

The aim of this paper is to use insights gained from the study of macroeconomic interdependence or co-movement to determine the extent to which aggregate outputs of African countries have been affected by bilateral trade with China, using the panel threshold regression model (Hansen, 1999). This means that the response of economic growth to bilateral trade may be nonlinear in the intensity of the latter. That is, a significant positive effect of bilateral trade on growth can be realized only after an economy crosses a threshold level of bilateral trade.For the most part, studies on growth effects of international trade derive measures of interaction on the assumption that the relationship between trade intensity and economic growth is linear. One exception to that assumption is Henry and Summers (2000), who document the existence of a threshold nonlinearity in the relationship between economic growth in Australia and that of the U.S. Along similar lines, we carried out a threshold autoregressive estimation which implies that the dynamic response to a shock may depend on the intensity of bilateral trade or the stage of a business cycle (Henry and Summers, 2000). Unlike the existing empirical literature on trade-growth nexus for African economies, our findings suggest a heterogeneous trade-growth nexus with the effect of bilateral trade intensity on Africa's economic growth being higher in countries whose trade intensity with China is higher compared to those with lower-intensity. However, although the effect of bilateral trade concentration on Africa's growth has been found for countries whose trade concentration is lower, the growth-effect of trade concentration for countries whose trade concentration is higher is unclear. These results are in contrast to some earlier literature relying on linear-based approaches which mask the parameter heterogeneity and may sometimes lead to inappropriate policy recommendations. Drawn implications emphasize the critical importance of addressing prevailing trade constraints as well as the provision of trade- capacity building for the Chinese market. An understanding of where the Chinese economy itself is going (eg. Garnaut et al, 2017), may similarly support more informed policy-making and investment decisions in Africa.

The paper is structured as follows. Section 2 overviews some major literature while Section 3 looks at methodological considerations and data. In section 4, results are presented and interpreted. Section 5 concludes the paper.

## 2. Literature

Explaining macroeconomic interdependence across countries has been a longstanding challenge in international economics. Theoretical contributions include international trade and investment spillovers, business cycle synchronization, international shocks and contagion, and interdependence. From a theoretical point of view, there is no explicit definition of the term "co-movement" in the literature, and there is no unique measure associated with the concept (Baur, 2003). This conceptual ambiguity has led to a variety of approaches to international macroeconomic interdependence. In this paper, macroeconomic interdependence refers to the degree to which individual African economies interact with that of China. This can be measured in all sorts of ways, but among the most important is the intensity with which macroeconomic variables—aggregate output, and prices in particular—affect each other across national borders.

Different researchers take different approaches to international macroeconomic interdependence, depending on the focus of their investigations. Major studies, mainly those on business cycles (e.g., Glick and Rogoff, 1995; Doyle and Faust, 2002), assume that shocks have permanent effects on economic growth (e.g., productivity/technology shocks). The latter class of models is in line with models that emphasize endogenous technological development and cross-country interactions in terms of technological diffusion (see, for example, Stock and Watson, 2003; Tan, 2007; Kose et al., 2008). Other studies deal with the formation of world business cycles (Selover and Jensen, 1999), the relationship between international monetary regimes and transmission of macroeconomic shocks (Dibooglu, 2000), or the sources and channels of propagation of international cycles (Canova and Dellas, 1993; Schmitt-Grohé, 1998; and Canova and Marrinan, 1998). Most of these studies have identified a number of variables that can lead to or mediate the transmission of a shock from one country to another. Among the latter, Backus et al. (1992), Bowden and Martin (1995), Baxter and Kouparitsas (2005), and Frankel and Rose (1998), to mention just a few, find evidence in favor of international output synchronization, with trade being the main channel of transmission. Frankel and Rose (1998) argue that trade helps shocks propagate from one region to others through demand linkages, because in a recession the demand of an economy for imports decreases and thus leads to a decline in the output of other countries. The trade repercussion model suggested by Dornbusch (1980) indicates that economic changes are transmitted from importing countries to exporting countries. Thus, international trade plays a role in macroeconomic spillovers. More to the point, Wald and Wood (2004) have commented that very little is known about the links between trade policy and economic growth. This is so in part because of sample heterogeneity and in part because of the presence of nonlinearity in the trade–growth nexus, which to some extent can explain the disagreement over the trade–growth relationship among researchers.

An increase in bilateral trade flows could lead to higher business cycle synchronization between the trading partners. Obviously, trade flows would strengthen the propagation of shocks in cases where demand shocks are dominant, especially through the effects on import demand. This effect could be either amplified or weakened, depending on the production structure and specialization patterns induced by trade flows (Espinosa and Sosa, 2007). Furthermore, studies such as that of Selover and Jensen (1999) have proposed a mode-locking explanation of business cycle synchronization which is relevant to the influence that China can exert on African economic growth. Mode locking is a phenomenon whereby systems with a tendency to oscillate, such as economies, will affect the timing of each other's oscillations in such a way as to bring about co-movement even if they are weakly linked. In this regard, Girardin (2005) suggests that output fluctuations can be strongly correlated between trading partners even in the absence of a high trade volume. In sum, Selover and Jensen (1999) and Girardin (2005) both support the idea that such a relationship is technically possible even in the presence of weakly trading partners.

More importantly, the mode-locking phenomenon implies existence of the twin characteristics of nonlinearity and a threshold effect. A number of studies (e.g., Barrett, 2001; Fackler and Goodwin, 2001; Goodwin and Piggot, 2001) have questioned the appropriateness of linear co-integration models, arguing that they ignore the transaction costs that might be incurred. Also, economic theory has identified the well-known channels through which trade can have an effect on growth. Specifically, trade is believed to promote the efficient allocation of resources, allow a country to realize economies of scale and scope, facilitate the diffusion of knowledge, foster technological progress, and encourage competition in both domestic and international markets that leads to optimization of production processes and to the development of new products (Busse, 2012). According to Mendoza (2010), the track record of trade openness bringing about economic growth is mixed, and the relationship between trade openness and economic growth is conditional. Chang et al. (2005) documented that the impact of increased openness on economic growth will be greater if the process is supported by higher investment in human capital, deeper markets, and the availability of infrastructure.

It is tempting to view the increase in bilateral trade intensity between Africa and China during the middle of the first decade of the 21st century as an indication of an effective engine of sustained economic growth rates in the long run, but when viewed in terms of trends in trade concentration/diversification there are theoretical grounds for concern. First, there has been mounting evidence that, rather than trade expansion, it is the composition and concentration of trade flows that matters when it comes to the trade–growth nexus (Hausmann et al., 2005). This means that both trade intensity and trade concentration/diversification determine the resulting effect on economic growth. In the case of African exports to China, Johnston et al. (2015) highlights the challenge indirectly via comparison of gravity model estimations within and across economic geography classifications, resource-rich and resource-poor (coastal and landlocked), finding that the resource-rich category near uniformly 'over-export' to China; and the resource-poor categories to similarly 'under-export' to China.

Second, trends in the Sino–African trade structure indicate that African countries are becoming more concentrated in the export of primary commodities rather than engaging in trade diversification. While this trend is often overlooked in the literature on Sino–African trade, it deserves a closer look insofar as trade concentration around primary commodities has long been recognized as one of the key drags on African economic growth.

To look at the trend in Africa's bilateral trade concentration, we focus on a period of rapid growth (2000–2009). Following Hinloopen and van Marrewijk (2001, 2006), we use the factor intensity classification that distinguishes between five broad factor-intensity categories (SITC Rev. 2 at the 2-digit level): primary products (e.g., meat, dairy, cereals, fruit, coffee, minerals, and oil), natural-resource-intensive products (e.g., leather, wood, pig iron, and copper), unskilled-labor-intensive products (e.g., textiles, clothing, ships, and footwear), human-capital-intensive products (e.g., perfumes, cosmetics, cars, and watches), and technology-intensive products (e.g., chemicals, electronics, tools, and electric items).

Tables A1 and A2 (in the Appendix) illustrate the factor-intensity breakdown of overall African trade in 2000 and 2009, as well as that of trade between Africa and China, trade between China and the rest of Asia, and trade between China and the developing countries in Asia[1] in those years. Table A2 highlights the obvious: In contrast to China's trade dynamics, African trade has undergone no structural change from unskilled-labor-intensive production to human-capital-intensive production or technology-driven industrial production. There has, however, been a fundamental shift in the share of China's technology-intensive exports to East Asia, from 31% in 2000 to 54% in 2009. The share of African primary commodity products exported to China during that period increased from 16% to 23%. Another significant factor in the overall trade growth in this category is a rapid increase in trade in oil and copper.

It is also interesting to note that even though the share of China's unskilled-labor-intensive exports to East Asia declined significantly (from 33% in 2000 to 18% in 2009), the share of Africa's exports to China in this category fell from 10% to 3% during the same period. The significance of this shift is demonstrated by the export/import ratio for African trade with China in unskilled-labor-intensive products, which was 1/3 in 2000 but declined to 1/7 in 2009. As both Africa and China are labor abundant, based on a simple Heckscher-Ohlin theory this shrinking unskilled-labor-intensive share could mean a missed opportunity for trade to enhance employment in Africa.

Moreover, although the share of human-capital-intensive goods exported from Africa2 (Africa except South Africa) to China changed slightly over the period 2000–2009, the share of goods in this category exported from China to Southeast Asia dropped from 19.7% to 12.8% (Table A2). The share of primary products (excluding oil) exported from Africa to China over this period, on the other hand, rose from 11.2% to 18.7% (Table A1); when oil is included, these figures are 16.5% and 23.8%, respectively.

The differences between patterns in China's trade with Africa and China's trade with Southeast Asia5 (Cambodia, Indonesia, Malaysia, Vietnam, and Thailand)[2] are even more revealing. China's share of technology-intensive products exported to Asia increased from 36% in 2000 to 45% in 2009, but its share of products in this category

[1] China's (and by extension East Asia's) changing export pattern matters insofar as it indirectly reflects the direction of technological change at the world economy level and how developing regions are reaping the potential benefits of globally available trade and technology. Hence, the shifting patterns of African exports (to China, the world, and the EU) can be studied by comparison with the corresponding categories of exports from Southeast Asia (Cambodia, Indonesia, Malaysia, Vietnam, and Thailand) to China.

[2] Most of these are developing countries that are in the process of reversing many factors that underlie Africa's generally poor performance on export diversification. In this respect, their trade patterns provide a useful benchmark for comparison.

imported from Southeast Asia5 increased from 39.5% to 53%. The trade data for Africa2, reported in Table A2, are even more revealing. The most dramatic change resulting from the exclusion of the South African data manifests in the technology-intensive trade category. Here, the share of exports from the rest of Africa, although twice as large in 2009 as in 2000 (in exports to both the world and China), is insignificant, especially in comparison to the share of exports to China from Southeast Asia5. Other evidence of such trade pattern differences is that the "primary products and petroleum oil" category accounts for nearly all of Africa's exports to China (96.32% in 2000 and 90.86% in 2009). In its total exports to the world, Africa2 has become more heavily concentrated in primary-commodity exports (76.79% in 2000 to 79.74% in 2009), although its trade with China reflects a reverse trend (from 96.32% in 2000 to 90.86% in 2009).

Furthermore, while a threshold effect has long been recognized in the growth–trade relationship, in most studies the determination of the threshold value has often been exogenously determined. This has often affected the reliability of the coefficients obtained, which in turn undermines the policy relevance of the conclusions drawn (Hansen, 1999). These considerations have led researchers such as Hansen (1999) and Henry and Summers (2000) to apply a nonlinear co-integration model in analyzing fluctuations in Australian economic growth. The presence of a trade–growth nexus has also been evidenced in the African context. Among others, Foster (2006) finds statistically significant thresholds in the relationship between growth and exports where these thresholds were determined by the countries' initial level of GDP per capita, the share of exports in GDP, and the growth of exports. Such an econometric improvement should permit testing of the prediction that the more intensive the trade between two countries (or the more openness to trade), the higher or more synchronous the macroeconomic cycles.

# 3. Methodological considerations and data

## 3.1. Panel threshold model

This paper follows Hansen (1999)'s panel threshold model to examine whether a bilateral trade-intensity or trade-concentration threshold exists in the trade–growth nexus in the context of China–Africa. The structure of the single-panel threshold model follows Hansen (1999) and Chen et al. (2011):

$$y_{it} = \mu_i + \beta_1^{'} x_{it} I(q_{it} \leq \gamma) + \beta_2^{'} x_{it} I(q_{it} > \gamma) + \varepsilon_{it}, \quad (1)$$

where the data are from a balanced panel; $i$ and $t$ denote indexes of the individual country ($1 \leq i \leq N$) and time ($1 \leq t \leq T$), respectively; $y_{it}$ and the threshold variable, $q_{it}$, are scalars; and $x_{it}$ is a vector of explanatory variables. Specifically, $y$ represents the real growth rate, and $x$ represents the investment ratio, the bilateral trade intensity, and the trade concentration. Following Temple (1999), the determinants of economic growth have been classified as either proximate sources or wider sources. The proximate sources usually include investment (in both physical and human capital), and the wider sources of growth comprise other sources that work by direct effects through the proximate sources, or by direct effects through TFP, including trade effects. Also, $I(\bullet)$ is an indicator function, $\mu_i$ is the fixed effect (or heterogeneity of individuals), and the error term, $\varepsilon_{it}$, is assumed to be independent and identically distributed: $e_{it} \sim iid(0, \sigma^2)$.

Equation (1) can be written as follows:

$$y_{it} = \mu_i + \beta^{'} x_{it}(\gamma) + \varepsilon_{it}, \quad (2)$$

where $\beta^{'} x_{it}(\gamma) = \begin{cases} \beta_1^{'} x_{it} I(q_{it} \leq r) \\ \beta_2^{'} x_{it} I(q_{it} > r) \end{cases}$.

As can be seen from (2), there are two regimes, depending on whether the value of the threshold variable, $q_{it}$, is less than or greater than the threshold value, $r$. The two regimes have different regression slopes, $\beta_1^{'}$ and $\beta_2^{'}$, respectively. Thus bilateral trade intensity affects economic growth only when it exceeds that threshold. If this prediction is correct, then we expect to find a statistically insignificant value of $\beta_1$ (for the low-trade-intensity regime), and a significantly positive value of $\beta_2$ (for the high-trade-intensity regime). Similarly, trade concentration affects growth only below a certain threshold. If this prediction is correct, we expect to find a statistically significant value of $\beta_1$ (for the low-trade-concentration regime), and a statistically insignificant or significantly negative value of $\beta_2$ (for the high-trade-concentration regime).

Averaging equation (2) over time yields

$$\bar{y}_i = \mu_i + \beta' \bar{x}_i(\gamma) + \bar{\varepsilon}_i, \tag{3}$$

where $\bar{y}_i = 1/T \sum_{t=1}^{T} y_{it}$ , $\bar{x}_i = 1/T \sum_{t=1}^{T} x_{it}$ , and $\bar{e}_i = 1/T \sum_{t=1}^{T} \varepsilon_{it}$ .

Subtracting equation (3) from (2), we obtain

$$y_{it}^* = \beta' x_{it}^*(\gamma) + \varepsilon_{it}^* \tag{4}$$

or, in vector form,

$$y_i^* = \begin{bmatrix} y_{i2}^* \\ \vdots \\ y_{iT}^* \end{bmatrix}, \; x_i^*(\gamma) = \begin{bmatrix} x_{i2}^*(\gamma) \\ \vdots \\ x_{iT}^*(\gamma) \end{bmatrix}, \text{ and } \varepsilon_i^* = \begin{bmatrix} \varepsilon_{i2}^* \\ \vdots \\ \varepsilon_{iT}^* \end{bmatrix}$$

Grouping the data for individuals into $Y^*$, $X^*$, and $\varepsilon^*$,

$$Y^* = \begin{bmatrix} y_1^* \\ \vdots \\ y_N^* \end{bmatrix}, \; X^*(\gamma) = \begin{bmatrix} x_1^*(\gamma) \\ \vdots \\ x_N^*(\gamma) \end{bmatrix}, \text{ and } \varepsilon^* = \begin{bmatrix} \varepsilon_1^* \\ \vdots \\ \varepsilon_N^* \end{bmatrix},$$

$$Y^* = \beta' X^*(\gamma) + e^* . \tag{5}$$

Ordinary least squares (OLS) is used to estimate $\beta$ for a given $\gamma$:

$$\hat{\beta}(\gamma) = (X^*(\gamma)' X^*(\gamma))^{-1} X^*(\gamma)' Y^* . \tag{6}$$

The vector of regression residuals is

$$\hat{e}^*(\gamma) = Y^* - X^*(\gamma)\hat{\beta}(\gamma), \tag{7}$$

where $\varepsilon = e$, This is minimized for SSE to estimate $\gamma$:

$$SSE_1(\gamma) = \hat{e}^*(\gamma)' \hat{e}^*(\gamma), \tag{8}$$

where

$$\hat{\gamma} = \arg\min_{\gamma} SSE_1(\gamma) \tag{9}$$

The estimated slope coefficient is $\hat{\beta} = \hat{\beta}(\hat{\gamma})$, the vector of residuals is $\hat{e}^* = \hat{e}^*(\hat{\gamma})$, and the estimated variance of the residuals is

$$\hat{\sigma}^2 = \frac{1}{N(T-1)} \hat{e}^{*'}(\hat{\gamma})' \hat{e}^*(\hat{\gamma}) = \frac{1}{N(T-1)} SSE_1(\hat{\gamma}). \tag{10}$$

In this paper, we assume that there is an optimal trade intensity that maximizes growth. The empirical threshold model is as follows:

$$y_{it} = \mu_i + \beta_1 x_{it} I(x_{it} \le \gamma_1) + \beta_2 x_{it} I(\gamma_1 < x_{it} \le \gamma_2) + \theta_1 z_{it} + e_{it} \tag{11}$$

for a balanced panel, where $i$ is the index of country $i$ and $t$ is the index of the time period (2000–2015). $z_{it}$ represents investment capital, $x_{it}$ is both an explanatory variable and the threshold variable, which represents trade intensity, and $\gamma_1$ is the threshold value.

**3.2 Testing for thresholds**

It is necessary to test whether the estimated threshold effect is statistically significant. The null hypothesis is $H_0 : \beta_1 = \beta_2$. Implementing the fixed-effect transformation of equation (4) under the null hypothesis of no threshold effects, we derive

$$y_{it}^* = \beta_1' x_{it}^*(\gamma) + e_{it}^*. \tag{12}$$

OLS is used to estimate the parameters, leading to the slope coefficient ($\tilde{\beta}_1$), the residuals ($\tilde{e}_{it}$), and the sum of the squared errors ($SSE_0 = \tilde{e}^{*'}\tilde{e}^*$). The likelihood ratio test of $H_0$ is given by

$$F_1 = (SSE_0 - SSE_1(\hat{\gamma}))/\hat{\sigma}^2. \tag{13}$$

The unidentified threshold, under $H_0$ leads to the problem of classical tests with a non-standard distribution. Hansen (1996) proposed using a bootstrap to estimate the model under the null and alternative hypotheses, equations (4) and (12), respectively, and computing the bootstrap value of the likelihood ratio test in equation (13). Repeating this step and computing the percentage of simulated statistics beyond the actual value, the asymptotic p-value of $F_1$ under $H_0$ may be found. If the p-value is less than the critical value, the null hypothesis of no threshold effect is rejected.

After determining the existence of threshold effects, we test whether the estimated $\hat{\gamma}$ is consistent with the true value, $\gamma_0$. According to Hansen (1999), when threshold effects exist, $\hat{\gamma}$ is consistent. However, there still exists the problem of the non-standard asymptotic distribution. Hansen (1999) derived an optimal method for the non-rejection region to test the threshold value, $\gamma$, where the null hypothesis is $H_0 : \gamma = \gamma_0$. The likelihood ratio test of $\gamma$ is as follows:

$$LR_1(\gamma) = \frac{SSE_1(\gamma) - SSE_1(\hat{\gamma})}{\hat{\sigma}^2}. \tag{14}$$

### 3.3. Data Description

Subject to the availability of annual data, 42 countries were used in the sample over the time period 2004–2014, organized in panel data format. Real GDP per capita (y) is gross domestic product divided by the midyear population expressed in constant 2005 U.S. dollars. The source of the GDP data is the World Development Indicators (World Bank, 2017). Bilateral trade intensity measures total merchandise (exports and imports) traded between China and individual African economies, expressed as a percentage of the total of Africa's trade to the world in a given year. The concentration index, also known as the Herfindahl–Hirschmann index, shows how exports and imports of individual countries or group of countries are concentrated on several products or otherwise distributed in a more homogeneous manner among a series of products. That index has been normalized to obtain values ranging from 0 to 1 (maximum concentration). The percentage of gross fixed capital formation was used as a proxy for the capital stock. Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories, expressed as a ratio to real national GDP. The data on bilateral trade, the concentration index, and the percentage of gross fixed capital formation were taken from the *UNCTADstat* Merchandise Trade Matrix (UNCTAD, 2017).

The descriptive statistics, namely means, standard deviations, and the minimum and maximum values of the variables for the full sample, as well as the number of observations, are summarized in Table A3. In general, our data set covers 188 countries. The descriptive statistics show that GDP growth is higher in the African countries, by an average of 3%. Interestingly, gross capital formation exhibits an average of 24%, which is lower than that of other developing regions. Regarding bilateral trade intensity with China, the sample country averages are around 23%, which is quite high compared to those of non-Asian developing regions. It is also notable that the bilateral trade concentration averages around 64%, which is quite high. Furthermore, the descriptive statistics suggest that the data exhibit high variability, which would indicate a lack of macroeconomic convergence among the African countries.

## 4. Empirical Results

A panel threshold regression was applied to test the prediction that bilateral trade intensity and concentration in Sino–African trade are nonlinearly related to economic growth in African countries. Before applying the threshold regression model, we tested for the existence of threshold effects between economic growth and bilateral trade intensity as well as between economic growth and trade concentration. The bootstrap method was used to obtain approximations of the *F* statistics, which were then used to calculate the p-values (for details, see Hansen, 1999). Table 1 presents the empirical results of the threshold test for the two alternative models, *the F-Statistics*, together with their bootstrap p-values. For each model, there were 1,000 bootstrap replications for the test *F-statistics*, procedure for each of the three tests (threshold value, F statistic, and p-value). The test statistic for a single threshold is highly significant, with bootstrap p-values of 0.003 and 0.086 for Models 1 and 2, respectively. Thus, we may conclude that there is strong evidence for threshold effects in the relationships between economic growth and both trade intensity and trade concentration.

**Table 1. Tests for threshold effects**

| Threshold effect test for bilateral trade intensity | | | | | |
|---|---|---|---|---|---|
| Threshold value | F | p-value | Critical Value of F | | |
| | | | 1% | 5% | 10% |
| 0.328 | 11.885 | 0.003** | 16.170 | 12.612 | 14.137 |
| Threshold effect test for trade concentration | | | | | |
| Threshold value | F | p-value | Critical Value of F | | |
| | | | 1% | 5% | 10% |
| 0.646 | 14.163 | 0.086* | 15.21 | 15.243 | 9.286 |

*Notes*: F statistics and p-values result from repeating the bootstrap procedures 1,000 times for each of the three bootstrap tests. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

From Table 2, it can be seen that the threshold value $\hat{\gamma}$ splits the observations into two regimes contingent on whether the threshold variable $q_{it}$ is smaller or larger than $\hat{\gamma}$. The regimes are distinguished by different regression slopes, $\beta_1$ and $\beta_2$. In the first regime, where the trade intensity ratio is less than 0.328, the estimate of the coefficient $\beta_1$ is 0.00148, which is significant at the 1% level and indicates that economic growth increases by 0.15% with an increase of 1% in the trade intensity level. In the second regime, where the trade intensity is greater than 0.328, the estimate of the coefficient $\beta_2$ is 0.00261, which is significant at the 1% level and indicates that economic growth increases by 0.26% with an increase of 1% in trade intensity.

Regarding the bilateral trade concentration, in the first regime, where the trade concentration index is less than 0.646, the estimate of the coefficient $\beta_1$ is 0.00693 which is significant at the 1% level and indicates that economic growth increases by 0.69% with a decrease of 1% in the trade concentration index (or an increase in the trade diversification index). In the second regime, where the trade concentration index is greater than 0.646, the estimate of coefficient $\beta_2$ is –0.0016 but it is not significant at any of the conventional levels. This means that the effect of increasing bilateral trade concentration on economic growth is not clear.

**Table 2 Estimated coefficients**

| | Estimated coefficient | S.E. | ***t-value*** |
|---|---|---|---|
| Model 1: Bilateral trade intensity | | | |
| $\beta_1$ | 0.00148 | 0.0041 | **3.5274*** ** |
| $\beta_2$ | 0.00261 | 0.0093 | **2.7917*** ** |
| $\theta_1$ | 0.02445 | 0.0046 | **5.4743*** ** |
| Model 2: Bilateral trade concentration | | | |
| $\beta_1$ | 0.00693 | 0.00156 | **4.4423*** ** |
| $\beta_2$ | –0.0016 | 0.2613 | **–0.0056** |
| $\theta_1$ | 0.0149 | 0.0063 | **2.364*** ** |

*Notes*: $\beta_1$ and $\beta_2$ are the estimated coefficients of the regimes $q_{it} \leq 0.328$ and $q_{it} > 0.328$, respectively in Model 1 (with trade intensity as threshold variable); . $q_{it} \leq 0.646$ and $q_{it} > 0.646$, respectively in Model 2 (with trade concentration as threshold variable) Entries in the S.E. column are values of the conventional standard error.
Values of $\theta_1$ are the estimated coefficients of the control variable "investment," which is proxied by gross fixed capital formation.
***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

As expected, gross fixed capital formation (which is a proxy for investment in fixed capital assets) to GDP (the control variable) has a positive effect on growth. Specifically, the coefficients for investment in fixed capital assets stand at 0.0244 and 0.015, respectively, and have been found to be significant in both alternative models.

Interestingly, when comparing the high-trade-intensity regime with the low-trade-concentration regime, it can be seen from Table 2 that the low-trade-concentration regime increases economic growth by a factor of 2.7 (0.00693/0.00261), while the high-trade-concentration regime is likely to represent a drag on economic growth (assuming that the coefficient estimated for that regime, with its current negative sign, is significant). Therefore, the results clearly show that the relationship between trade concentration and economic growth (i.e., the value of the slope) varies in accordance with differences in the trade structure.

Based on the above findings, we are compelled to conclude that in the economic interactions of African countries with China, there is an optimal bilateral trade concentration ratio below 64% at which they will begin to reap the diversification premium. Such a premium is likely to be twice as high as the boost in economic growth provided by trade intensity alone. These results are consistent with the recent theories of international trade according to which it is not trade per se that matters for economic growth but rather the structure of trade. (For further information, see Hausmann et al., 2005.)

Another interesting finding drawn from the results of this study is that African countries can be classified into four major groups in terms of the growth effects of their bilateral trade with China (see Table A4), namely, (1) those with low trade intensity and trade concentration (which includes Kenya, Namibia, Egypt, Mozambique, and Cote d'Ivoire), (2) those with low trade intensity and high trade concentration (which includes Rwanda, Guinea, Malawi, Algeria, Zambia, Botswana, and Chad), (3) those with high trade intensity and low trade concentration (which includes Mauritius, South Africa, Niger, DRC, Tanzania, Mauritania, and Togo), and (4) those with high trade intensity and high trade concentration (which includes Angola, Congo, Sudan, CAR, Benin, and others). Overall, policymakers in these groups need to tailor their trade policy with China depending on their institutional and trade-related constraints. This emphasis on specific policy focus depending on trade intensity and concentration resonates with the suggestion by Johnston et al. (2015) that policy priorities with China should differ for Africa economies along lines of economic and economic geography endowment - and highlight in fact that China's policy set of up to the end of the first decade of this century was inconsistent with long-run growth and development of Africa.

Policy-wise, to further maximize their growth windfalls in their bilateral interactions with China, the countries in the aforementioned group (4), with high trade intensity and high trade concentration, should prioritize the transformation of their export pattern from commodities to manufactures much more rapidly than the rest of the region. The countries in group (2), with high trade intensity and low trade concentration, need to expand their trade volume, perhaps by attracting more foreign investment from China, subject to the degree to which their endowments compare with those of China. Furthermore, in the countries in group (1), with low trade intensity and low trade concentration, policymakers should provide incentives and support to allow imports of intermediate and capital goods, and support production of manufactured goods for export while aiming at expanding their export volume to China. Lastly, the countries in group (3), with high trade intensity and low trade concentration, would do well to steer their economies toward intra-industrial trade or further integration into the China-led global value chains.

To integrate the china-led global value chains, it must be recognized that the gains from synchronization of outputs via trade derive not only from Africa's ability to collaborate with China, but also from investments and policy reforms that reduce trade costs; which includes investment aiming at improving logistic, telecommunication and transport infrastructure. On the latter, investment in efficient physical infrastructure is a central variable in maximizing gains from macroeconomic synchronization in the long term as well as an important policy objective. Johnston (2015) and Johnston and Rudyak (2017) suggest that the China-Africa economic relationship should be moving in this direction.

Despite the evidence we have found in regard to Sino–African trade, a word of caution is in order. While the growth-augmented trade model is useful in understanding the degree of interdependence between China and African economies, such an approach is necessarily faced with the question of the level of sophistication to be incorporated into the modeling framework—notably, the distinction between the effects of trade and those of investment. Indeed, empirical verification of such a distinction is beyond the scope of this paper. Nevertheless, these limitations may not be severe in our case, since much of China's investment in Africa has been closely tied to its trade agenda in the region.

## 5. Conclusion and implications

In this paper, the impacts of the intensity and concentration of Sino–African bilateral trade, which are incorporated as threshold variables, on economic growth in African countries has been examined. Broadly, the empirical results of the panel threshold regression show that there exists a significant nonlinear relationship between economic growth in African countries and their respective bilateral trade intensity and trade concentration with China. Specifically, three important findings emerge from the analysis. First, the evidence points to the presence of threshold effects in Sino–African bilateral trade and economic growth in African countries. Although the findings confirmed the existence of two regimes for each relationship (i.e., bilateral-trade intensity and the trade–growth nexus), the evidence does not support a threshold effect of high trade concentration on economic growth. Interestingly, threshold effects of high trade intensity, low trade intensity, and low trade concentration on economic growth have been found.

Second, it was found that African countries can be classified into four major groups in terms of the growth effects of their bilateral trade with China: low trade intensity and low trade concentration, low trade intensity and high trade concentration, high trade intensity and low trade concentration, and high trade intensity and high trade concentration. This classification has profound implications in terms of policy aimed at, say, shifting the pattern of (mainly) their exports to China away from commodities and toward manufactured goods.

Third, from a policy-making perspective in regard to commodity-exporting countries, the above findings indicate that each of the four aforementioned groups would need to adopt a different strategy to maximize its trade benefits vis-à-vis China. Also, too high an export concentration could prevent Africa from reaping the benefits of its trade with China unless existing constraints are urgently addressed. Such constraints could be impeding the ability of African countries to offer diversified export products (i.e., with less trade concentration) at a time when the demand for primary commodities by China is expected to increase significantly.

Going forward, our findings raise additional issues to be addressed in regard to the capacity of African economies to capitalize on the growing trade integration with China. Unlike in other regions, the surge in economic interactions between Africa and China is not associated with the trend toward intra-industrial trade or vertical integration. This is not even the case for countries with high trade intensity and low trade concentration with China. To circumvent existing constraints, investment in efficient physical infrastructure and reduction in technological gaps between the two regions become central policy objectives. Ultimately, exploitation of the advantages of Chinese growth requires investment by African governments and enterprises which seek to export to the diverse Chinese regions. In this regard, African countries are likely to need assistance from foreign donors in the way of trade-capacity building for the Chinese market.

As regards future research, in order to assess China's direct impact on growth opportunities in African countries, it is essential to map more systematically the trade links between China and Africa. There are likely to be many unrecognized opportunities for removing blockages and improving the terms of trade. Particular attention would need to be paid to technology and skill upgrading.

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# APPENDIX

## Table A1. Africa, Africa-China, and China-Asia3's Trade Pattern Based on Factor Intensities

(Exports and imports in % of total)

| | Trade in 2000 | | | | | | Trade in 2009 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Africa | | Africa-China | | China-East Asia3 | | Africa | | Africa-China | | China-East Asia-3 | |
| | Exports | Imports | Exports | Imports | Exports | Imports | Export | Imports | Exports | Imports | Exports | Imports |
| **Primary products (excl. petroleum oil)** | **11.08** | **11.61** | **11.22** | **5.94** | **11.81** | **3.53** | **13.38** | **14.10** | **18.76** | **3.01** | **5.43** | **3.45** |
| Primary products (incl. 33.3–33.4 petroleum oil) | 19.12 | 19.74 | 16.55 | 6.86 | 13.71 | 6.05 | 22.73 | 24.95 | 23.81 | 3.50 | 6.84 | 5.98 |
| **Resource intensive** | **4.13** | **4.30** | **5.05** | **2.85** | **5.02** | **4.15** | **3.87** | **3.77** | **5.13** | **2.32** | **3.13** | **3.32** |
| **Unskilled labor intensive** | **9.54** | **9.60** | **10.19** | **36.91** | **33.65** | **11.48** | **8.75** | **8.02** | **3.32** | **24.58** | **18.49** | **3.60** |
| **Human capital intensive** | **19.38** | **19.23** | **10.88** | **13.54** | **11.51** | **14.29** | **17.77** | **17.27** | **10.12** | **14.06** | **11.49** | **14.77** |
| **Technology intensive** | **40.52** | **40.33** | **52.50** | **34.48** | **31.47** | **60.27** | **39.23** | **39.20** | **53.79** | **49.61** | **54.00** | **68.27** |
| **SITC not specified** | **7.31** | **6.79** | **4.83** | **5.37** | **4.64** | **3.76** | **7.66** | **6.80** | **3.82** | **5.93** | **6.05** | **4.06** |
| **Total** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Notes: The classification of products according to factor intensity is based on Hinloopen and Marrewijk (2004). SITC 33.3 and 33.4
a) Primary products include SITC 0, 1, 2, 3 (excl. 33.3, 33.4), and 4.
b) Resource intensive products include: SITC 61, 63, 66.1, 66.2, 66.3, 66.7, 67.1, and 68.
c) Unskilled labor intensive products include: SITC 65, 66.4, 66.5, 66.6, 79.3, 81, 82, 83, 84, 85, 89.4, and 89.5.
d) Nonspecified SITC subsectors include SITC 29, 59, 66, 69, and 79.
e) East Asia3 consists of Hong Kong, Japan, and the Republic of Korea.
Source: Author's compilation and calculations; data from the UN Comtrade database, 2010

## Table A2. Africa2, Africa2-China, and China-Southeast Asia's External Trade Patterns Based on Factor Intensities

(Exports and imports in % of total)

| | Trade in 2000 | | | | | | Trade in 2009 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Africa2 | | Africa2-China | | China-Southeast Asia5 | | Africa2 | | Africa2-China | | China-Southeast Asia5 | |
| | Exports | Imports | Exports | Imports | Exports | Imports | Export | Imports | Exports | Imports | Exports | Imports |
| **Primary products (excl. petroleum oil)** | **21.33** | **18.65** | **20.91** | **13.96** | **17.09** | **33.27** | **23.78** | **15.62** | **12.95** | **3.34** | **10.30** | **30.19** |
| Primary products (incl. 33.3– -33.4 petroleum oil) | 76.79 | 31.61 | 96.32 | 15.47 | 22.86 | 45.08 | 79.74 | 24.26 | 90.86 | 3.40 | 13.99 | 36.58 |
| **Resource intensive** | **7.87** | **3.38** | **1.42** | **1.53** | **2.96** | **5.07** | **6.85** | **3.81** | **6.07** | **4.52** | **2.96** | **1.60** |
| **Unskilled labor intensive** | **4.26** | **6.78** | **0.23** | **27.67** | **11.53** | **2.86** | **2.75** | **4.38** | **0.35** | **11.22** | **17.37** | **1.93** |
| **Human capital intensive** | **2.61** | **21.42** | **1.53** | **20.00** | **19.71** | **5.67** | **2.30** | **25.79** | **0.77** | **28.52** | **12.80** | **4.50** |
| **Technology intensive** | **1.96** | **28.60** | **0.19** | **25.17** | **36.82** | **39.54** | **3.26** | **32.61** | **0.81** | **40.21** | **45.64** | **53.81** |
| **SITC not specified** | 6.52 | 8.21 | 0.31 | 10.16 | 6.13 | 1.77 | 5.09 | 9.14 | 1.13 | 12.12 | 7.24 | 1.57 |
| **Total** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Notes: The classification of products according to factor intensity is based on Hinloopen and Marrewijk (2004). SITC 33.3 and 33.4
a) Primary products include SITC 0, 1, 2, 3 (excl. 33.3, 33.4), and 4.
b) Resource intensive products include SITC 61, 63, 66.1, 66.2, 66.3, 66.7, 67.1, and 68.
c) Unskilled labor intensive products include SITC 65, 66.4, 66.5, 66.6, 79.3, 81, 82, 83, 84, 85, 89.4, and 89.5.
d) Nonspecified SITC subsectors include SITC 29, 59, 66, 69, and 79.
e) Africa2 denotes all sub-Saharan African countries excluding South Africa; Southeast Asia5 comprises Cambodia, Indonesia, Malaysia, Viet Nam, and Thailand.
Source: Author's compilation and calculations; data from the UN Comtrade database, 2010

**Table A3. Descriptive Statistics**

| | GDP | GCF | TRADEINT | CONCENT |
|---|---|---|---|---|
| Mean | 3.026181 | 0.242632 | 0.235001 | 0.645993 |
| Median | 2.814159 | 0.235310 | 0.138919 | 0.611534 |
| Maximum | 124.5367 | 0.614687 | 0.970207 | 0.999955 |
| Minimum | -61.42059 | 0.015252 | 0.005663 | 0.183346 |
| Std. Dev. | 7.516945 | 0.092254 | 0.232195 | 0.230275 |
| Observations | 474 | 474 | 474 | 474 |

**Table A4.**