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Analyzing the Evolution of China-Africa Economic Integration: A Wavelet Approach

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Abstract This study analyzes the evolution of Africa's degree of economic integration with China from 1993 to 2019. The study period encompasses a number of China-Africa bilateral economic treaties, which the literature claims are prolific and have significantly strengthened Africa's degree of economic integration with China. We develop a theoretical argument that, if this assertion holds, the integration indicator must reflect a long-run upward trend that is less obstructed by noise. To validate this argument, we use a wavelet approach and find no evidence necessitating failure to reject the null hypothesis of no periodicity, suggesting that the integration indicator was statistically noisy over the study period. This finding suggests that interpreting the evolution of China-Africa economic integration primarily through bilateral economic pacts can be deceptive. The interpretation should instead be exploratory in nature to unpack some hidden motivations associated with this integration. Our preliminary investigation revealed that the Angola Model is primarily driving China-Africa economic integration. Therefore, it is plausible to argue that China-Africa economic integration is perpetuated to exploit natural resources rather than to enhance hard infrastructure development in Africa, as purported in the literature.

Keywords: Angola model, China-Africa, economic integration, wavelet analysis

JEL Classifications: F6, F15, F63

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I. Introduction

Africa is rich in natural resources and has "a resilient labor force that in difficult circumstances delivers innovation and growth" (UNDP, 2011, p. 3), but it faces a number of economic development challenges. According to the UN (2019) and UNCTAD (2019), Africa is home to more than two-thirds of the world's least developed countries. These countries are characterized by low domestic capital investments, poor industrialization, high youth unemployment rate, high

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inequality, and poor hard infrastructure, specifically, energy, transportation, and communication. In some cases, Africa's economic development challenges have been exacerbated by a deteriorating governance framework and poor macroeconomic policy. The continent has one of the highest proportions of the unskilled and semi-skilled labor force, and capacity is generally low, particularly in high-tech sectors. According to UNDP (2011), these challenges demonstrate the continent's economic integration potential. Despite commendable initiatives toward regional economic integration (REI) over the previous two decades, Schiere (2011), Gumede (2019), and Leshoele (2020) argued that progress has been slow and difficult. Among the widely praised initiatives are the African Continent Free Trade Area, the promotion of the Accra Declaration to catalyze the continent's economic and political integration, and the establishment of regional economic communities (RECs), such as the Southern African Development Community (SADC), the Common Market for Eastern and Southern Africa, and the Economic Community of West African States (ECOWAS). However, little is said about the 2012 Africa Union's Program for Infrastructure Development in Africa (PIDA), which was launched to achieve connectivity in transport, communication, and energy across the RECs and thus the entire continent by 2040.

Gumede (2019) and Leshoele (2020) argued that differences in political systems among African countries impede REI. Without dismissing their contributions, we believe that Africa's REI initiatives have focused more on soft infrastructure to liberalize trade on the continent, for example, tariff reductions and the establishment of customs unions across the continent. Although soft infrastructure development initiatives are positive steps, Vhumbunu (2016) argued that Africa should prioritize the PIDA initiative to accelerate its REI plan and achieve significant sustainable development benefits. This implies that economic integration goes beyond trade liberalization and unification of regulations, standards, and political systems; it includes investment in hard infrastructure. As indicated by Jin (2015), PIDA is a costly project when compared with Africa's financial capacity, so less progress has been achieved to date. Therefore, we can argue that Africa requires international economic integration to enable a renaissance in its regional hard infrastructure projects, compensating for the demerits of having limited finances to invest in these projects.

The evolving China-Africa economic cooperation appears to align with the missing factor in Africa's successful pursuit of REI. Specifically, over the last two decades, Africa has experienced a surge in Chinese economic activities, with a greater share allocated to hard infrastructure, mining, and other construction projects (Kamoche, Gunessee and Kufuor, 2021). Several bilateral agreements between the two economies have accompanied this development. The trans-continental analyses conducted by Jian and Xiaoqin (2015), Jin (2015), Vhumbunu (2016), Aiping and Shun (2018), and Kamoche, Gunessee and Kufuor (2021) reveal that the China-Africa economic integration plays a critical role in enhancing hard infrastructure development in all Africa's RECs across all sectors of transport, energy, and communication. Thus, an interesting aspect

of the China-Africa economic integration is the role it could play in Africa's REI by enhancing the PIDA project.

However, some studies have expressed concerns regarding the China-Africa economic cooperation. For instance, Pigato and Tang (2015) and Jureńczyk (2020) argued that the cooperation is driven by China's motive to exploit natural resources in Africa. Meanwhile, Gill and Karakülah (2019) contend that China is leveraging its geopolitical agenda by trapping African countries into unsustainable loans. In terms of geopolitical agenda, the present study contends that Africa may be targeted as the soft spot due to its weak institutional framework and dire need for physical capital. Despite these concerns, substantial literature supports the notion that international economic integration provides development opportunities for developing countries, depending on the degree of integration. According to Abesadze (2017, p. 1), for developing countries, international economic integration "has become the object of the purpose of everyday political, economic and social-cultural life." Nonetheless, "the success of the development of national economies immediately depends on the degree of the countries' participation in the processes of integration." (*ibid*, 2017, p.1). Arribas, Pérez, and Tortosa-Ausina (2007) also asserted that balanced participation in an economic integration process promotes a higher level of integration. For China-Africa economic integration, in particular, Schiere (2011)[1] suggested that Africa's bargaining position in the integration process determines the outcome of the cooperation. As a result, to capitalize on the opportunities that come with international economic integration, the continent must improve its participation in trade, investment, loans, and other financing arrangements with China. Recently, Kamoche, Gunessee, and Kufuor (2021) emphasized that the China-Africa economic integration still needs to be scrutinized to inform relevant policies regarding Africa's participation in this engagement. This justifies the necessity to estimate the degree of economic integration between China and Africa. Gill and Karakülah (2019) argued that the empirical analysis of China-Africa economic cooperation has been constrained by a lack of reliable data on China's financial flows to Africa. However, various initiatives, such as the China-Africa Research Initiative (CARI) and the Global Chinese Official Finance Database of AidData, have since been launched to address this data problem and promote empirical analyses based on high-quality data.

The current study makes two contributions. First, using the CARI dataset, we attempt to reveal what data can tell us about China's economic integration with Africa, which has recently been speculated and debated without empirical evidence due to data ambiguities. As stated by Gill and Karakülah (2019) and Were (2018), some assessments of China-Africa economic cooperation are ambiguous due to a lack of reliable data on bilateral Chinese financial flows to African countries. The second contribution is methodological in nature, with the study

1) Schiere (2011) proposed institutional reforms as the main initiative required for Africa to improve its participation in the China-Africa economic integration.

employing wavelet analysis to examine the evolution of international economic integration among economies. Economic integration processes have been extensively analyzed using descriptive statistics (see, e.g., Arribas, Pérez, and Tortosa-Ausina, 2007; Abesadze, 2017). Conclusions drawn from descriptive statistics are influenced by assumptions about the underlying data generation process. For example, suppose the mean of the data is constant over time and the data are stationary. In reality, this is not the case because most economic time series data are not stationary. A wavelet approach addresses these shortcomings.

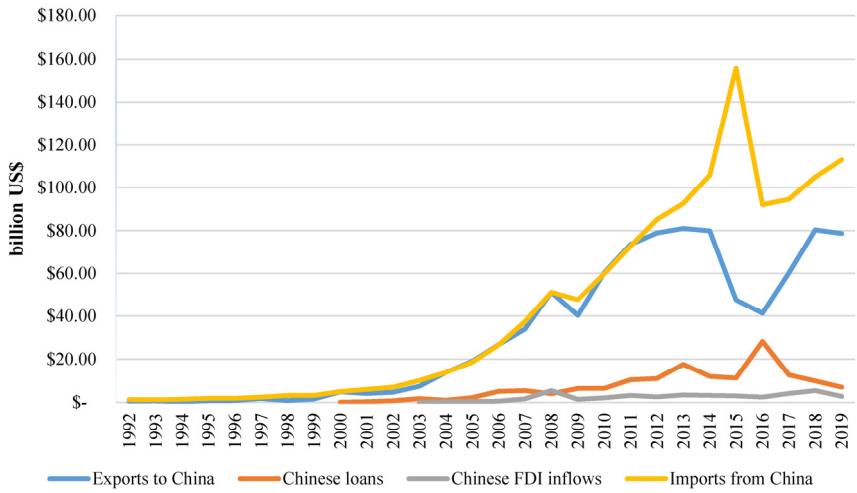
The remainder of the paper is divided into four sections. Section 2 provides an overview of China-Africa economic cooperation. Section 3 outlines the empirical strategy. Section 4 presents and discusses the results. Finally, Section 5 concludes the study.

II. China-Africa Economic Engagement

China's engagement with African countries dates back to the colonial era in Africa. However, until the Forum on China-Africa Cooperation (FOCAC) was established in 2000, the cooperation was more political than economic (Jureńczyk, 2020). FOCAC was established to promote multilateral consultations and collective engagement between China and Africa. As shown in Figure 1, from the establishment of FOCAC to its fifth Ministerial Conference in 2012, Africa's total exports to China increased from US$ 4.85 billion to US$ 78.91 billion, whereas China's total exports to Africa increased from US$ 5.01 billion to US$ 85.13 billion. Additionally, China's total foreign direct investment (FDI) flows and loans to Africa grew to US$ 2.52 billion and US$ 10.95 billion from less than a billion in 2003 and 2000, respectively. According to Aiping and Shun (2018) and Were (2018), China became Africa's largest trading partner and financier beginning in 2009, whereas Africa became China's fourth-largest investment hub. However, both Chinese FDI flows and loans to Africa have remained very low relative to trade flows.

It has frequently been argued that not only are the trade flows impressive, but so is the rate of increase, as illustrated in Figure 1. However, the surge in China-Africa bilateral trade volumes that appears to have favored China between 1992 and 2019 is equally concerning. According to Pigato and Tang (2015), Africa has become a home for cheap and sub-standard Chinese products, whereas China has benefited from the natural resources in Africa through its investment-growth-oriented policy. Similarly, Begu et al. (2018) emphasized that China's primary motivations for partnering with Africa are to secure markets for its products and to exploit natural resources. It is also concerning that China has consistently financed Africa with more debt (Chinese loans) than investment (Chinese FDI inflows).

Figure 1. Chinese financial flows to Africa



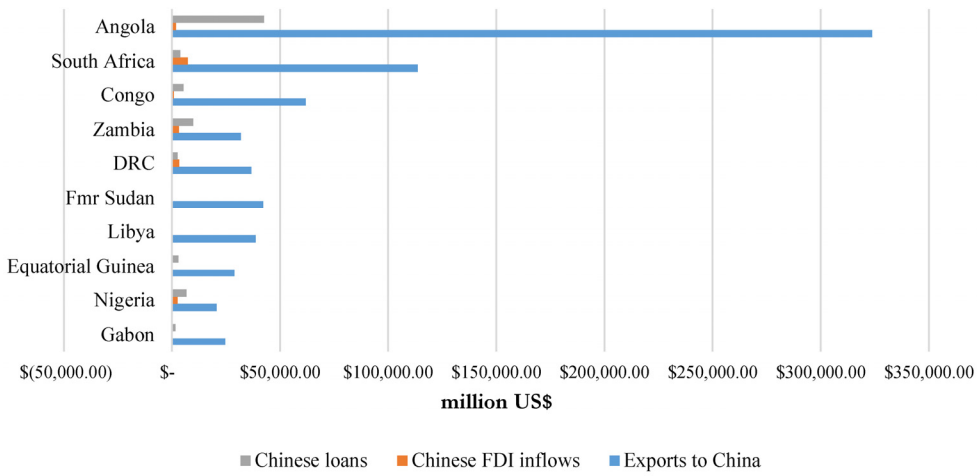
(Source) Authors' computation using the China-Africa Research Initiative dataset (CARI, 2021).

According to Jin (2015), by the end of 2012, China had signed bilateral investment protection treaties and established a Joint Economic and Trade Commission mechanism with 32 and 45 African countries, respectively. Jin (2015) also noted that as promised at the fifth FOCAC Ministerial Conference in 2012, China began implementing three measures to enhance China-Africa economic engagement in 2013. These measures were intended to expand investment and financing cooperation, increase development assistance to Africa, and support Africa's REI. To support these measures, China implemented a US$20 billion finance plan, and loan agreements were negotiated in areas, such as infrastructure, agriculture, manufacturing, and the development of small- and medium-sized enterprises. The most prolific trade partnership, namely China's One Belt One Road Initiative, also known as the Belt and Road Initiative (BRI), was launched in 2014 to develop Africa's hard infrastructure, allowing Africa to connect with Asia (particularly China) and Europe, ease trade, and reduce trade costs (Jian and Xiaoqin, 2015; Vhumbunu, 2016; Machado, 2021). Accordingly, during a visit to Africa in 2014, Chinese Premier Li Keqiang expressed China's desire to strengthen its economic engagement with Africa in areas, such as roads, railways, ports, sea lanes, electric power, and transportation. The third FOCAC summit and seventh ministerial conference, held in Beijing in September 2018, provide further evidence of China's intentions toward Africa. During the summit, Chinese President Xi Jinping pledged $60 billion in aid, investment, and loans to Africa's hard infrastructure projects (Regissahui, 2019).

The preceding narrative gives an impression that following FOCAC and BRI, the China-Africa bilateral trade, and Chinese investments and loans for infrastructure projects have increased in a considerable number of African countries. Nonetheless, in terms of China-Africa bilateral trade, CARI's trade data show that Africa's exports to China are concentrated in a

few countries, whereas China's exports are evenly distributed across all African countries. Figure 2 shows that approximately 75.3% of Chinese finances (exports to China, Chinese loans, and Chinese FDI inflows) flow to just ten African countries, with more than 45% concentrated in only two SADC countries (Angola (33.8%) and South Africa (11.5%)).[2] In contrast with Regissahui (2019), Figure 2 demonstrates that Angola, not South Africa, is the largest African exporter to China. South Africa is the continent's largest importer of Chinese goods and the recipient of Chinese FDI (CARI, 2021). South Africa's economic relations with China can be exceptional from other African countries on the merit of the Brazil, Russia, India, China, and South Africa economic block. Using the AidData dataset on Chinese financial flows to Africa, Gill and Karakülah (2019) also depicted that Angola is the world's third-largest recipient of Chinese official finances after Russia and Pakistan, respectively.

Figure 2. Top ten (10) recipients of Chinese financial flows for the period 1992-2019



(Source) Authors' computation using CARI dataset (CARI, 2021).

Thus far, China-Africa economic cooperation appears to be unbalanced and overstated. Therefore, conducting an empirical study to ascertain the level of Africa's participation in this economic cooperation, as suggested by Kamoche, Gunessee, and Kufuor (2021), and analyzing the periodic progress of this economic integration are meaningful. Addressing these questions will allow for relevant policy recommendations on whether or not the continent is reaping the expected benefits of its economic integration with China. The following is the empirical strategy that will guide this study.

2) Authors' estimations using CARI's dataset (CARI, 2021). The top five (5) recipient countries of Chinese financial flows are member states of SADC (Angola (33.8%) and South Africa (11.5%)) and COMESA (Congo (6.3%), Zambia (4.1%), and DRC (3.9%). The bottom 5 are member states of COMESA (Former Sudan (3.9%) and Libya (3.5%)), ECOWAS (Nigeria (2.8%)), and other AU member states (Equatorial Guinea (3%) and Gabon (2.4%)).

III. Empirical Strategy

Although the degree of economic integration has often been estimated and assessed using a descriptive statistics (Arribas, Pérez and Tortosa-Ausina, 2007; Abesadze, 2017), this study complements the method with the wavelet analysis. Descriptive statistics offer a starting point to analyze the economic integration process. However, they do not capture structural breaks, and time and frequency domains in a unified framework. Conclusions derived from descriptive statistics are subjected to assumptions about the underlying data generation process. For example, suppose the data's mean is constant over time and does not follow any trend. In reality, most time-series data in economics are not stationary, so this is not true. A wavelet approach accounts for all of these disadvantages.

According to Arribas, Pérez and Tortosa-Ausina (2007) and Abesadze (2017), the economic integration process is subject to the openness of economies. Thus, the degree of economic integration increases as the economies become more open. In this respect, economic integration indicators are specified in the form of financial flows between the economies and "the proportionality of these financial flows to the size of the economies" (Arribas, Pérez, and Tortosa-Ausina, 2007, p. 7). Abesadze (2017) estimated Georgia's integration coefficient with the rest of the world as the arithmetic mean of the financial flows (normalized as a percentage of Georgia's GDP). Given Africa's capital demand, it is ideal to take this approach and estimate the integration coefficient as an average of all Chinese financial flows to Africa. However, because of the disparity between export flows and other financial flows, as shown in Figure 1, adopting Abesadze's (2017) approach may result in underestimated coefficients. Thus, we utilize export flows as a share of the host economy's GDP to estimate Africa's level of economic integration with China. The coefficient ranges from 0% to 100%, and for assessment, we adopt the mechanical distribution principle utilized by Abesadze (2017), where 0%-33.3%, 33.3%-66.6% and 66.6%-100% represent low, average, and high degree of integration, respectively. The mechanical distribution principle is thus used to assess Africa's participation in this economic integration process.

Subsequently, we apply a wavelet approach and use export growth (%) as an integration indicator[3] to analyze how Africa's degree of economic integration with China has progressed in accordance with the bilateral economic arrangements discussed in Section 2. We contend that if the China-Africa bilateral economic treaties increased Africa's degree of economic integration with China, as indicated in the literature (see, e.g., Jian and Xiaoqin, 2015; Jin, 2015; Aiping and Shun, 2018; Regissahui, 2019; Kamoche, Gunessee and Kufuor, 2021), then the integration indicator should reflect a long-run upward trend that is less obstructed by noise.

3) This measure is widely considered in various integration indicators databases. See, for example, the Asian Regional Integration Centre database.

This argument is framed into the following null hypothesis:

H0: The China-Africa bilateral economic pacts significantly impact the periodic evolution of Africa's degree of economic integration with China.

The null hypothesis can be accepted if there is no evidence for periodicity or white noise in the integration indicator. Otherwise, the interpretation of Africa's periodic evolution of economic integration with China must be exploratory in order to reveal some hidden aspects associated with this integration. In other words, we apply wavelet analysis to determine whether the periodic evolution of Africa's degree of integration with China should be hypothesized or exploratorily interpreted based on their bilateral economic treaties. This study utilizes CARI's dataset on China's financial flows to African countries (CARI, 2021). The study period (1993-2019) is constrained by data availability; China-Africa bilateral trade data are currently available from 1992 to 2019.

A. Wavelet analysis

Wavelet analysis is a method for compressing, processing, and analyzing non-stationary time series data to extract useful information about how the data changes over time (Crowley, 2005; Nguyen & He, 2015). Wavelet analysis allows one to analyze time series data at different frequencies and time locations (Rua, 2012). Wavelet analysis has received significant attention in economics for assessing stock market integration (Marfatia, 2017), business cycles (Fidrmuc, Korhonen, & Poměnková, 2014; Rua, 2012), and forecasting of stock prices (Nguyen & He, 2015). Despite the wavelet analysis's potential value in analyzing non-stationary financial univariate, bivariate, and multivariate time-series data (Rosch & Schmidbauer, 2018), it remains a relatively unexplored tool in the phenomena of economic integration based on financial flows, such as trade, investment, loan, and aid. This adds to the originality of the current study.

Wavelet functions can be expressed in a variety of ways, each with its own set of features, depending on the field and goal of the study (Rhif, Abbes, Farah, Martínez, & Sang, 2019).[4] Following Rua (2012), Marfatia (2017), and Rosch and Schmidbauer (2018), this study employs the "mother" Morlet wavelet, which is the most widely adopted wavelet function to analyze the frequency structure of univariate, bivariate, and multivariate time-series data in financial and macroeconomics fields. The mother Molete wavelet can be specified as follows:

$$\psi(t) = \pi^{-\frac{1}{4}} e^{i\omega t} e^{\frac{-t^2}{2}} \quad (1)$$

4) Rhif et al. (2019) provided a detailed account of the application of various forms of wavelet functions in different fields.

The parameter ω represents the "central frequency of the wavelet" (Marfatia, 2017, p. 36) or "rotation rate in radians per time unit," where a complete revolution is equivalent to 2π radians (Rosch and Schmidbauer, 2018, p. 4). Furthermore, ω "controls the number of oscillations within the Gaussian envelope," such that if ω is increased, better frequency but poorer time localization is obtained and vice versa (Rua, 2012, p. 14). Hence, to obtain a balanced localization between frequency and time, several studies including Rua (2012), Marfatia (2017), and Rosch and Schmidbauer, 2018) recommended ω to be set to 6. This implies that an inverse frequency in time units is equivalent to $2\pi/6$.

1. Theoretical underpinning: Analysis of univariate time series using wavelets

Given the univariate time-series data (integration indicator) $x(t)$, the mother Morlet wavelet transform ($W_x(\tau,s)$) can be specified as follows:

$$W_x(\tau,s)=\sum x(t)\frac{1}{\sqrt{s}}\psi^*\left(\frac{t-\tau}{s}\right) \tag{2}$$

Equation (2) depicts the convolution of the series with a set of "daughter" wavelets formed by the mother wavelet, with * and $1/\sqrt{s}$ representing the complex conjugate and the normalization factor,[5] respectively (Rosch & Schmidbauer, 2018). The exact position of a daughter wavelet in the time domain is identified by the translation or shifting parameter τ (shifted by a time increment of dt), whereas its coverage in the frequency domain is determined by the scaling or dilation parameter s (the wavelet expands if $s>1$ and contracts if $s<1$). The scaling parameter s is inversely proportional to frequency (low scales capture high frequency, whereas high scales capture low frequency). Moreover, the value of s is a fractional power of 2, implying that the mother wavelet is scaled or dilated by a power of 2.

$$s_{\min}2^{j.dj}, j=0,\ldots,J \tag{3}$$

where J denotes the total number of scales.

As in Rosch and Schmidbauer (2018), the present study converts scales to periods by fixing the minimum and maximum scales via the selection of the minimum and maximum period of interest, respectively, through the conversion or Fourier factor $6/2\pi$. This Fourier factor is known for consistently estimating the sinus waves of known frequencies. To efficiently estimate equation (2), we use the WaveletComp package, which employs fast Fourier transform algorithms,

5) The normalization factor "ensures unit variance to make wavelet transformations comparable across scales and time."(Marfatia, 2017, p. 36).

as demonstrated by Rosch and Schmidbauer (2018).

The modulus of any period component of $x(t)$ can be used to extract the wavelet amplitude and its evolution over time. In high frequency (low scale/short-run) cases, however, mere modulus tends to produce underestimated wavelet amplitudes. WaveletComp package uses the rectified version of mere modulus (see equation (4)) to generate robust wavelet amplitudes in any case of the frequency domain.

$$Amplitude_x(\tau,s)=\frac{1}{\sqrt{s}}\left|W_x(\tau,s)\right| \tag{4}$$

Squaring equation (4) yields a wavelet power spectrum (equation (5)), which is interpreted in the same way as the time-frequency wavelet energy density.

$$Power_x(\tau,s)=\frac{1}{s}|W_x(\tau,s)|^2 \tag{5}$$

In the case of Gaussian noise (white noise) $[e\sim N(0,\delta^2)]$, the normalization factor $1/s$ ensures that the expectation of a wavelet power spectrum at each time and scale matches the series' variance. Thus, normalizing $x(t)$ after detrending it is a standard approach for generating a wavelet power measure that corresponds to the unit-variance of Gaussian noise and can be compared with estimates from other series. By default, the WaveletComp package provides optional detrending via local polynomial regression and performs internal normalization. An image plot is typically used to visualize the wavelet power spectrum, and the time-period domain is the default in WaveletComp. However, customizing the axes enables conversion to the time-scale or time-frequency domains.

A default process is also used to efficiently determine the power peak within a band of adjacent periods, after which the peak is retrieved and added to the power spectrum. The same is true for the influence cone, which excludes areas with edge effects. Meanwhile, simulation algorithms are employed to evaluate significance when testing the null hypothesis of no periodicity, and there are several options to test against, for which surrogate time series are offered. "White noise, shuffling the time series provided, time series with a similar spectrum, AR, and ARIMA" are among the options (Rosch and Schmidbauer, 2018, p. 6). Contour lines added to the wavelet power spectrum highlight areas of high significance. In this study, the overall periodic strength phenomena are analyzed using a time-averaged wavelet power spectrum, as provided by WaveletComp.

The local wavelet phase, which can be wrapped to represent an angle in the interval $(-\pi,\pi)$, represents displacements of periodic events moved over the time domain that is relative to

the localizing origin τ:

$$Wavelet\ \ Phase\ _x(\tau,s)= A(W_x(\tau,s))= \tan^{-1}\left(\frac{L(W_x(\tau,s))}{R(W_x(\tau,s))}\right) \tag{6}$$

In some cases, analyzing specific phase images may aid in understanding the timing (in terms of phase shifts) of structural breaks in periodic events. WaveletComp can retrieve and plot (average) phase pathways for single periods or period bands. It can also map the overall phase image.

Because the mother Morlet wavelet transform is a bandpass filter with a high degree of redundancy, $x(t)$ can be smoothed and regenerated by adding a set of reconstruction waves:

$$x(t)= \frac{dj.\sqrt{dt}}{0.766.\psi(0)}\sum_s \frac{R(W_x(.,s))}{\sqrt{s}} \tag{7}$$

Equation (7) is based on an empirical reconstruction factor of 0.766 recommended by Torrence and Compo (1998) for full reconstruction. However, there is an option to recover the mean and variance of the detrended series, especially for selective reconstruction.

IV. Estimated Results

A. Africa's degree of economic integration with China

As stated in Section 3, we quantify Africa's degree of economic integration with China by normalizing export flows to China as a percentage of Africa's GDP. The available data cover a relatively long study period (1992-2019), allowing us to uncover the pre-FOFAC phase that other studies did not examine due to data limitations. Table 1 summarizes the integration coefficients for the study period. On average, the degree of economic integration realized by the entire African continent, Angola as Africa's largest recipient of Chinese financial flows, and the top ten recipients of Chinese financial flows was 1.65%, 14.35%, and 2.76%, respectively. According to the mechanical distribution principle (Abesadze, 2017), these integration coefficients are far below 33.3%, implying that the level of integration was very low during the study period, as was African countries' participation in this integration process. Similarly, Jureńczyk (2020, p. 45) claimed that African countries have remained reluctant "toward China's exploitative attitude."

Table 1. *Degree of Economic Integration Coefficient*

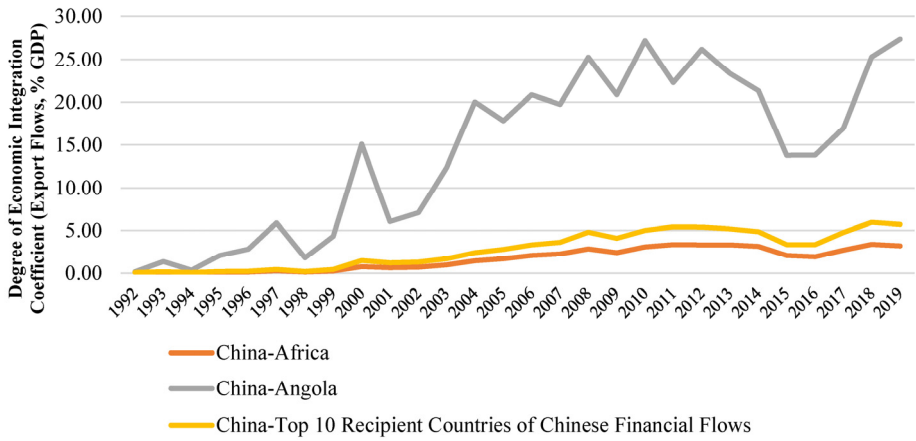
Year	China-Africa (%)	China-Angola (%)	China-Top 10 Recipient Countries of Chinese Financial Flows (%)
1992	0.09	0.16	0.07
1993	0.10	1.34	0.14
1994	0.07	0.35	0.07
1995	0.12	2.06	0.18
1996	0.13	2.79	0.21
1997	0.26	5.90	0.43
1998	0.12	1.78	0.18
1999	0.24	4.32	0.42
2000	0.74	15.09	1.46
2001	0.64	6.04	1.20
2002	0.70	7.11	1.29
2003	0.94	12.38	1.67
2004	1.44	20.03	2.40
2005	1.68	17.80	2.77
2006	2.05	20.87	3.32
2007	2.23	19.75	3.60
2008	2.84	25.28	4.81
2009	2.39	20.87	4.08
2010	3.06	27.23	5.00
2011	3.34	22.29	5.42
2012	3.30	26.21	5.41
2013	3.31	23.39	5.20
2014	3.12	21.35	4.88
2015	2.05	13.77	3.34
2016	1.91	13.81	3.36
2017	2.68	16.95	4.78
2018	3.39	25.31	5.98
2019	3.20	27.42	5.72
Mean	1.65	14.35	2.76

(Source) Authors' estimations.

Figure 3 indicates that Africa's degree of economic integration with China has consistently fallen below the trajectory of the top ten recipient countries of Chinese financial flows over time. Furthermore, both graphs resemble the China-Angola trajectory. Based on this finding, it is reasonable to argue that 1) China-Angola economic relations have a significant impact on Africa's degree of economic integration with China; and 2) contrary to what has been emphasized in the literature (see, e.g., Jian and Xiaoqin, 2015; Jin, 2015; Vhumbunu, 2016; Aiping and Shun, 2018; Kamoche, Gunessee and Kufuor, 2021), China's economic engagement

with African countries is not balanced across Africa in general and across major Africa's RECs in particular. The engagement seems to be strategically targeted to a few African countries.

Figure 3. China-Africa's degree of economic integration, 1992-2019



(Source) Authors' estimations.

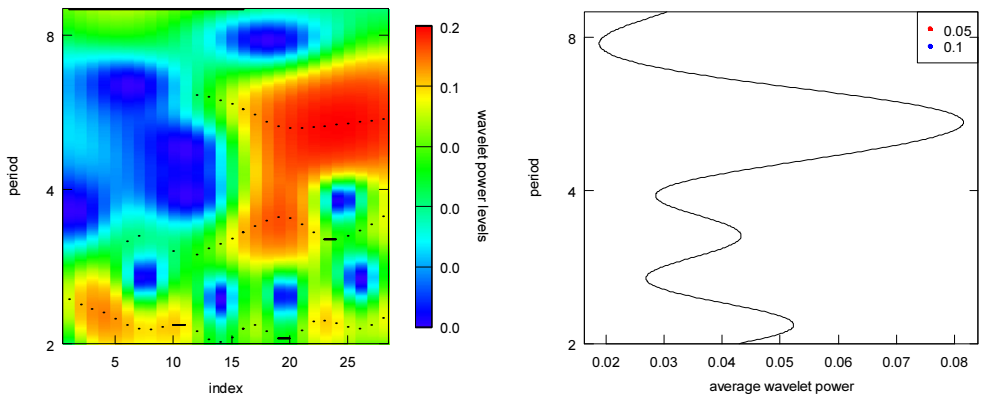
B. The evolution of China-Africa's degree of integration in line with their bilateral economic pacts

Following an assessment of the nature of Africa's degree of integration with China, we apply the wavelet approach to analyze how the integration has progressed over time, taking into account the bilateral economic pacts signed between the economies, as discussed in Section 2. The left part of Figure 4 shows the time-frequency plot (also referred to as the wavelet power spectrum) of the integration indicator (export growth (%)). The horizontal axis depicts the time domain in 5-year intervals (i.e., 1993-2019), whereas the vertical axis depicts the frequency domain in time units (years). Thus, the wavelet power spectrum in Figure 4 depicts how Africa's degree of integration with China has progressed from 1993 to 2019, with different frequency bands capturing the short-run (high frequency) and long-run (low frequency) nature of the fluctuations. The color gradation in this context reflects the nature of the integration indicator's fluctuations, where red (blue) depicts a region with a higher (lower) rate of fluctuation.

The wavelet scalogram (Figure 4) can be described in three frequency domain phases. First, it shows a low fluctuation rate of the integration indicator at low frequencies (long-run/for more than 8 years) during the study period. Second, at frequencies lasting more than 2 years but less than 8 years, there is a shift from a lower to a higher rate of fluctuation in 2007, indicating that the integration indicator fluctuated more frequently beginning in 2007, although with some episodes where the fluctuation rate was temporarily lower. Finally, at high frequencies

(short run for less than 2 years), the fluctuation rate was moderately high from 1995 to 2002 before falling to a relatively low level from 2002 onward.

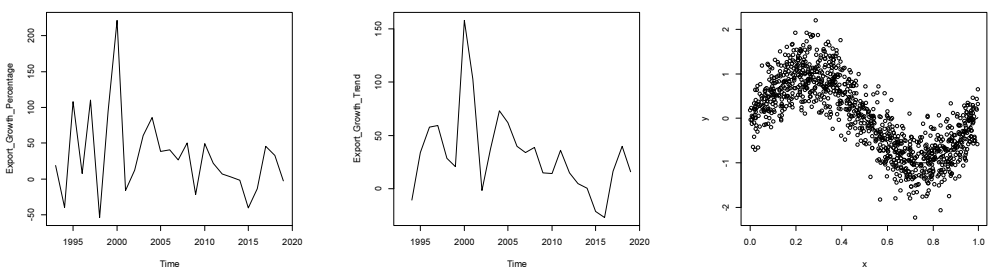
Figure 4. Wavelet scalogram for China-Africa economic integration[6)]



(Source) Authors' estimations using WaveletComp package in R.

However, no white contours exist to demarcate the areas of significance in the entire scalogram, as supported by the time-averaged wavelet power spectrum (right part of Figure 4). This means that the integration indicator was statistically noisy over the study period. Thus, we reject the null hypothesis of no periodicity at the 10% significance level. In essence, the integration indicator's trend is non-linear, with the downward path characterized by various bilateral economic arrangements between China and Africa (Figure 5).

Figure 5. Original and denoised trends of the integration indicator



(Source) Author's estimations using R.

The first graph in Figure 5 depicts the integration indicator's original series trend, whereas the middle and last graphs are denoised trends, smoothed with a simple moving average of

6) We attained the same results for Angola and the top ten recipients of Chinese financial flows. The outputs can be provided upon request.

order (2) and wavelet soft threshold function in the WaveThresh package, respectively. The smoothed graphs show that the evolution of Africa's degree of economic integration with China is roughly curvilinear, with an upward trend (1993-2000), a downward trend (2000-2016), and another upward trend (2016-2019). This integration indicator has seasonality. In. light of our null hypothesis, the notion that China-Africa bilateral economic pacts significantly intensified Africa's degree of economic integration with China is challenged in this study. This finding supports the assertion by Begu et al. (2018), who stated that the evolution of China-Africa economic integration is difficult to predict because various ambiguous factors influence it. Therefore, we can argue that interpreting the evolution of Africa's economic integration with China through bilateral economic pacts may mislead policy developments. The question we ought to answer now is what factors influence the evolution of China-Africa's degree of economic integration? Findings in Section 4.1 indicate that Africa's degree of integration with China depends on Chinese financial flows to Angola. Perhaps investigating the Angola Model can help us answer this question.

C. The Angola model

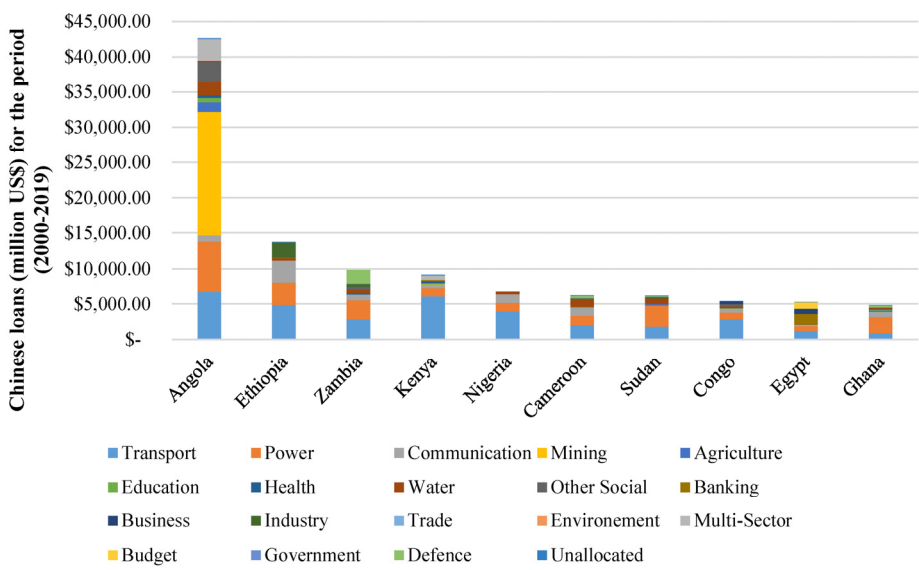
The Angola Model is a term used to refer to the economic cooperation between China and Angola (Begu et al., 2018; Haifang, 2017; Jureńczyk, 2020; Machado, 2021). According to Haifang (2017), the World Bank coined this term to acknowledge the success of the China-Angola bilateral barter economic cooperation in infrastructure for resources. The literature highlights that the Angola Model results from a 2004 Sino-Angola agreement in which China's Exim Bank granted Angola a US$2 billion oil-backed loan for post-war reconstruction. Thus, the Angola Model is primarily characterized by oil-guaranteed Chinese loans to Angola. Perhaps it is due to such collateral arrangements that China's debt financing conditions for poor institutional quality countries like Angola are less favorable than those of the Western financiers. According to the Angola Model, Angola will be Africa's largest oil exporter to China and Africa's largest recipient of Chinese loans provisioned for hard infrastructure development. Although the former is true, the latter is debatable. Figure 6 shows that mining projects receive more Chinese loans in Angola than hard infrastructure projects. China appears to market its loans in exchange for hard infrastructure development while targeting the natural resources. The infrastructure-for-resources rhetoric is therefore rife with misrepresentation. With this evidence, it is reasonable to adjust the rhetoric to "Chinese loans for resources." Thus far, the debt trap anxieties are justified, as the sustainability of Chinese loans in Angola is most likely to be dependent on oil price fluctuations. Furthermore, the Angola Model adheres to the South-South cooperation principles[7];

7) Jureńczyk (2020) specified that the Angola model is based on the South-South cooperation principles, which mainly include mutual benefits, sovereignty and mutual respect, equity, solidarity, bilateralism, multilateralism, partnership,

however, on the ground, China tends to be pragmatic. This is another common misunderstanding worthy to be noted.

According to Jureńczyk (2020), China has adopted the Angola Model in other resource-rich African countries, such as the Democratic Republic of the Congo (DRC), Equatorial Guinea, Nigeria, Sudan, South Africa, and Zambia. These countries are among Africa's top ten exporters to China (Figure 2), implying that the bulk of their exports to China are natural resources. In terms of hard infrastructure development, Figure 6 indicates that Chinese loans for transportation infrastructure are prioritized over other infrastructure projects (energy and communication). Although this finding can be linked to the BRI, Were (2018) claimed that Chinese loans are mainly provisioned for transportation infrastructure to facilitate natural resource transportation from Africa to China. For example, in Ethiopia and Kenya, ports and railway lines are being built. Furthermore, according to Haifang (2017) and Were (2018), the provision of Chinese debt financing for infrastructure and other construction projects in Africa is an initiative aimed at creating jobs for Chinese contractors; hence, the majority of these projects are completed by Chinese firms with little participation from local firms and labor force. Arguably, Chinese financiers prioritize hard infrastructure projects in Africa to improve production and networking for the benefit of Chinese firms, all at the expense of Africa.

Figure 6. Africa's top 10 recipients of Chinese loans

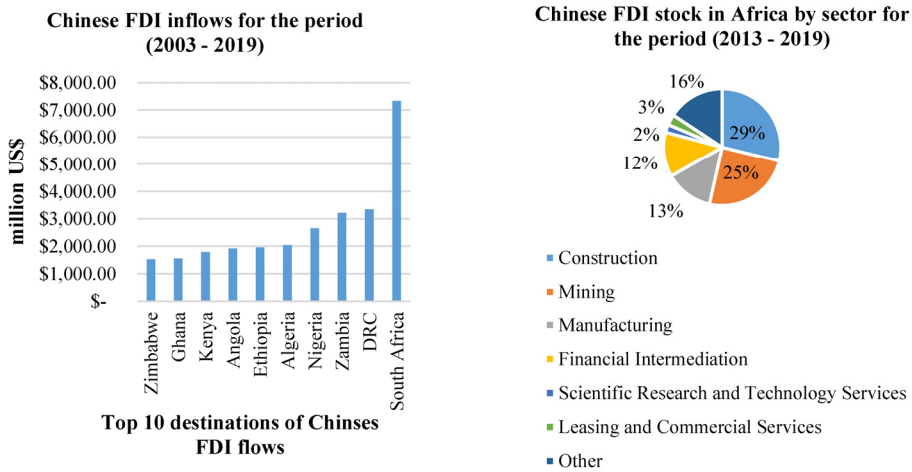


(Source) Authors' computation using CARI's dataset (CARI, 2021).

collective self-reliance, and shared responsibility.

Several studies (see, e.g., Haifang, 2017; Jureńczyk, 2020; Machado, 2021) did not account for Chinese FDI in the Angola Model as clearly as Chinese loans and natural resource exports to China. According to Begu et al. (2018), the China-Angola investment model is based on the Angola Model, and Chinese firms have expanded this investment concept to other African countries, thanks to substantial support from their state-owned banks. If the Angola Model is applied to Figure 7, one can conclude that Chinese investors prioritize resource-rich countries (e.g., Zimbabwe, DRC, Angola, Zambia, Nigeria, and South Africa) to exploit raw materials for their home manufacturing industry. Geo-strategically located countries, such as South Africa, Kenya, Tanzania, and Ethiopia, are also prioritized in the transport infrastructure projects to boost raw material exports from Africa to China. Moreover, it can be argued that Chinese investments in power and communication infrastructure projects are a strategy to benefit their economic activities in Africa. In general, Chinese FDI flows to Africa have remained low in comparison with Chinese loans (Figure 1).

Figure 7. Chinese foreign direct investment in Africa



(Source) Authors' computation using CARI's dataset (CARI, 2021).

Thus far, we have undisputed pointers to argue that China's focus in Africa is to gain access to natural resources rather than to assist Africa in its hard infrastructure development projects. Therefore, China-Africa's degree of economic integration is essentially nothing without natural resources. In essence, since the Chinese government appears to have significant support for Chinese economic activities in Africa through their banks, the evolution of China-Africa economic integration can be linked to Chinese foreign policy and their investment-oriented-growth strategy. However, as Schiere (2011) pointed out, this can be a win-win deal if African countries can improve their participation in trade, investment, loans, and other financing arrangements with China.

Meanwhile, the participation of all African countries is very low, as shown in Table 1.

V. Conclusion

This study analyzed the period evolution of China-Africa's degree of economic integration for 1992-2019. The study period encompasses the two major bilateral treaties between China and Africa, namely, FOCAC and BRI. The literature asserts that these pacts are prolific and have significantly intensified the degree of economic integration between China and all of Africa's major RECs, resulting in an increase in Chinese financial flows to Africa. Moreover, Chinese economic activities are enhancing infrastructure development in Africa. However, recent studies have argued that some assessments of China-Africa economic cooperation are ambiguous due to a lack of reliable data on bilateral Chinese financial flows to African countries. This study uses CARI's dataset. CARI was established in 2014 to address data ambiguities regarding bilateral China-Africa financial flows and promote robust empirical examination of China-Africa related studies based on high-quality data. According to the theoretical argument developed in this study, if these pacts have significantly strengthened Africa's degree of economic integration with China, as asserted in the literature, then the integration indicator must reflect a long-run upward trend that is less obstructed by noise. We used a wavelet approach to validate this argument, and we found no evidence to accept the null hypothesis of no periodicity, indicating that the integration indicator was statistically noisy, let alone non-linear, over the study period. In contrast to previous research, this finding suggests that interpreting the evolution of China-Africa economic integration primarily through bilateral economic treaties may mislead policy developments. The interpretation should instead be exploratorily driven to unpack some hidden motives associated with the integration. Our exploratory investigation revealed two crucial aspects: 1) Africa's economic integration with China is biased toward Angola, and China tends to have implemented economic integration elements of the "Angola Model" in other resource-rich African countries. Moreover, 2) African countries' participation in this integration process has remained low, despite China's pragmatic approach. In light of these findings, it is meaningful to argue that the China-Africa economic integration is perpetuated to exploit natural resources rather than to improve hard infrastructure development in Africa, as purported.

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