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Investigating the Causality Relationship between Construction Flows and Aggregate Economy: Evidence from Sudan

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ABSTRACT

This research examined the lead-lag relationship between construction output and total GDP in Sudan applying the Granger causality test. The analysis employed data pertaining to the performance of the Sudanese economy during the period prior to the secession of Southern Sudan 1982-2009. The results of this research reveal that construction flows tend to be driven by economic growth, not vice versa. This implies that the construction sector is growth-dependent and not growth-initiating. The magnitude of this relationship has been interpreted in a form of a formula derived, applying the Johansen Co-integration test, to demonstrate the long-run equilibrium between construction flows and total GDP in the Sudan.

المستخلص

تمَّ في هذه الورقة دراسة العلاقة بين الأداء الاقتصادي وإنتاج قطاع التشييد في السودان باستخدام اختبار غرانغر للسببية. وقد ارتكز التحليل على المعلومات الإحصائية الخاصة بالسودان ما قبل انفصال الجنوب خلال الفترة من 1982 وحتى 2009. أظهرت النتائج أن أداء قطاع التشييد في السودان يتبع نمط الأداء العام للاقتصاد وليس العكس. وأن القطاع يُحفَّز بالنمو الاقتصادي ولكن لا يُحفِّزه. وقد تم استنباط معادلة لتقدير انتاج قطاع التشييد بناءً على جملة انتاج الاقتصاد وذلك باستخدام اختبار جوهانسون للتكامل بغرض تأطير العلاقة بين تدفقات التشييد والناتج المحلي الإجمالي بالسودان.

Keywords: construction output; GDP; causality relationship; Granger causality; Johansen co-integration; Sudan

1. Introduction

Construction contributes about 4%, on average, to the total GDP of the Sudan, implying the importance of the construction sector to the Sudanese economy. A report by the World Bank [1] reveals that recent improvements in infrastructure in all parts of Sudan have had a strong impact on the growth of construction expenditure per capita, contributing 1.7 percentage points. The growth of construction output per capita is following the same fluctuating trend as the construction output growth [2]. The sector seems to experience higher volatility than the economy as a whole and its sub-sectors in terms of rates of growth [3]. The nature of the linkage between construction output and the entire economy in the Sudan has not been examined. It is not yet known whether the construction sector leads lag the economy or vice versa. The aim of this study is to investigate the lead-lag relationship between construction flows and the total output of the Sudanese economy. The research findings will be helpful in setting proper and adequate strategies for both the economy and the construction sector.

2. Literature Review

Many researchers [4-8, 9] and international organizations [10-11] have investigated the relationship between the output of the construction sector and gross domestic product (GDP), concluding the existence of a strong positive correlation. However, few studies have focused on examining the causality relationship between construction and the overall economic performance or between construction and its counter parts in the economy. Notwithstanding the consensus about the existence of a strong relationship between the construction sector and other sectors of the economy, the nature and dynamism of this relation remains controversial as four possible forms of relationships exist: (a) causality runs from GDP to construction activity; (b) construction leads economic growth; (c) bi-directional causal relationship between construction and GDP; and (d) dynamic causal relationship [18].

Empirical evidence from studies adopting co-integration and granger causality tests in different countries – Barbados [12], Hong Kong [13], and

Singapore [14] - have concluded that the GDP leads lag construction output. This conclusion implies that any expansion of construction activity tends to be preceded by an increase in economic output. In other words, the level of construction activities is determined by the level of GDP rather than being autonomous. Bynoe [12] stated that other sectors of the economy have a predictive power over changes in construction output. Tse and Raftery [15] arrived at similar conclusions by investigating the causality between money supply and construction flows in Hong Kong.

On contrary, research results in some countries – Ghana [16] and Pakistan [17] conclude that the growth in the CI granger-causes the growth in GDP, not vice versa. They argue that causality seems to run from construction to GDP, implying that construction flows precede GDP whereas GDP does not precede construction flows. Tse and Ganesan [13] argue that construction booms tend to aggravate the inflationary pressure within the economy rather than contributing to GDP growth. In the long term, however, higher construction flows are likely to increase GDP by adding to the nation's capital stock. This argument opposed that of Giang and Pheng [18] who suggest that construction leads lag economic growth in the short-run while economic growth has a long-term effect on construction.

The conclusions drawn from previous researches reveal that relationship between construction output and GDP is not the same in all economies and appears to be context specific. The investigation of this relationship for a specific country is crucially important in setting the strategies and plans that targets the construction industry in general and the construction sector in specific. Indeed, the nature of this relationship calls for specific policies to be adopted and specific decisions to be made. Thus, it is important for policy makers to know and understand the nature and dynamism of the relationship between the construction sector and the economy as a whole and other sectors of the economy as well.

3. Sudan's Economy: An overview

Instability is inexorably and inextricably characterizing the performance of the Sudanese economy. The economy of Sudan has been buffeted by civil war,

political instability, adverse weather, weak world commodity prices, a drop in remittances from abroad, and counterproductive economic policies [2]. Since independence, the economy of Sudan has experienced high fluctuations in its performance varying from negative to positive rates of growth. The country's economic growth record has been set turbulent course reflecting fluctuating pattern of growth. Following the year 1996, macro-economic indicators showed signs of improvement as a result of massive oil production and export. In addition, inflation rates, which peaked during 1991-95, tapered off during later years and were accompanied by continued decline in government expenditures compared to GDP. After the end of war in the South following the historic Comprehensive Peace Agreement (CPA) in 2005, the Sudanese economy was given a breath to perform well and became more thriving, buoyant and promising in terms of general performance.

However, the economy witnessed a severe drawback following the secession of Southern Sudan in July 2011 (Table 1, Figure 1, and Figure 2). Sudan is now facing serious challenges not only in its economic performance, but politically as well. Growth in the economy has shrunk dramatically from 13.6% in 2015 to 4.3% in 2017 and gives signs of shrinking further [19]. The economy has lost three-quarters of its oil production and revenue which was representing about 90% of the country exports. This comes even as inflation hits 48% and rises dramatically; foreign currencies reserves decrease significantly; and local currency (SDG) devaluates devastatingly. The Central Bank has devalued the Sudanese pound, which has been in free-fall on the black market since the South's secession. The gap between the official exchange rate of foreign currencies (i.e., US Dollar) and the rate in the black market has widened dramatically [20]. The official exchange rate as of February 2019, as reported by the CBOS, was 47.5, while the exchange rate in the black-market hits as high as 80 SDG/$ and even 90 SDG/$ if paid by cheque. Significant lack of liquidity is the most recent issue that has come to the scene since October 2018. The external debt is approaching $50 billion and forming a huge burden on the economy.

Table 1: Total GDP and Output of Construction Sector in Sudan 1982-2017

YEAR	TOTAL GDP	BUILDING & CONSTRUCTION	YEAR	TOTAL GDP	BUILDING & CONSTRUCTION
1982	7,040.0	381.9	2002	17,231.8	390.0
1983	7,185.2	450.8	2003	18,316.0	418.0
1984	6,825.3	378.8	2004	19,257.0	524.0
1985	6,396.6	350.7	2005	20,344.4	628.3
1986	6,742.9	305.3	2006	22,353.0	690.0
1987	7,701.8	367.7	2007	24,156.5	749.1
1988	7,676.3	349.8	2008	26,032.0	811.0
1989	8,361.9	326.6	2009	27,630.0	890.0
1990	7,904.5	408.4	2010	27,630.0	1,000.0
1991	8,498.2	589.6	2011	29,400.0	900.0
1992	9,056.7	337.1	2012	26,950.0	930.2
1993	9,471.0	445.4	2013	27,092.7	949.1
1994	9,566.3	477.6	2014	28,283.3	1,004.3
1995	10,140.0	506.2	2015	29,041.3	900.0
1996	11,312.4	214.7	2016	33,000.0	600.0
1997	11,997.6	229.9	2017	34,700.0	700.0
1998	12,986.0	600.9			
1999*	13,536.0	376.0	Values in thousands Sudanese Pounds		
2000	14,672.0	283.0			
2001	16,256.0	370.0			

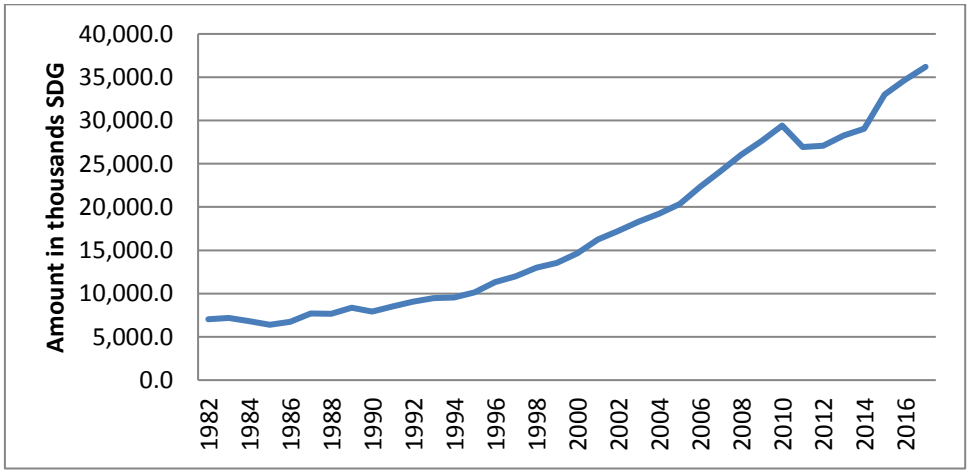

Figure 1: Total GDP in Sudan 1982-2017

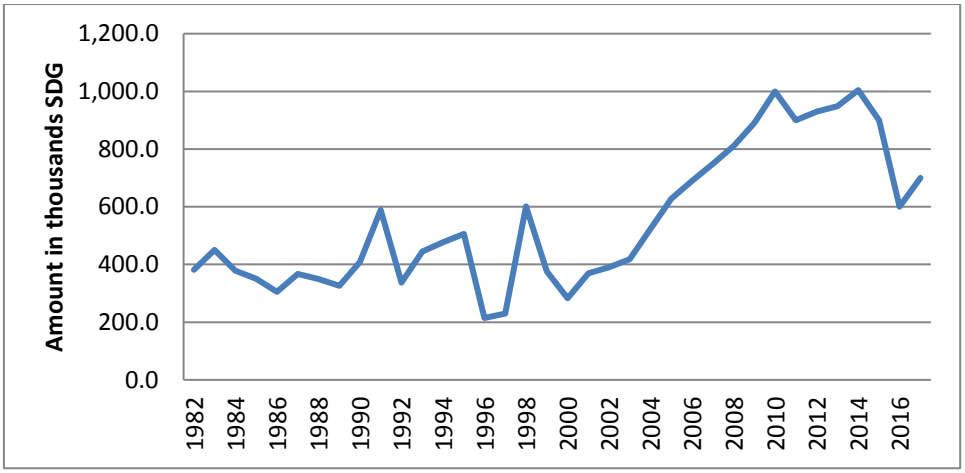

Figure 1: The output of the Building and Construction Sector 1982-2017

4. The Economic Significance of the Sudanese Construction Industry

Statistics report that the construction sector in Sudan contributes to the total GDP of the country by about 4%. It is important to note that the construction sector in the Sudan lacks a published definition [21], with fluid boundaries that do not show what is included and/or excluded in reporting its output. The official statistics and reports - published by the Central Bank (CBOS), Ministry of Finance (MoF), and the Central Bureau of Statistics (CBS) - limit the data about the gross output of the construction sector to the construction and rehabilitation projects executed by: the Roads and Bridges National Authority (RBNA), General Corporation for Irrigation and Earth Moving Works (GCIEMW) and Dams Implementation Unit (DIU). These statistics do not report the amount nor the value of construction activities other than the aforementioned. The information about executed projects for infrastructure (i.e. water supply, electricity, communication) is not available. Thus, most of the formal sector activities are not reported let alone the informal sector. It is quite obvious that agriculture, mining and quarrying, manufacturing, electricity and water as well as transport and telecommunication involve substantial construction activities. If the construction activities incorporated into other sectors of the economy are accounted for, the sector's share in GDP will be much higher than it appears. Consequently, the role of construction in the Sudanese economy is believed to be more significant than what appears in official statistics and reports [2]. Furthermore, the Sudanese construction industry is faced by multitude challenges hindering its development [2-3, 22-23].

Regardless to its real boundaries, the highest share of construction as percentage of GDP was witnessed in 1991 (6.9%). The lowest share (1.9%) was experienced in 1996, 1997 and 2000. It was evident that the end of war in southern Sudan and the oil production have contributed to the growth of the construction sector output and even building its capacity [23]. The relationship between construction output and economic performance in Sudan has never been examined elaborately. Thus, this research is believed to be the first of its kind as it investigates the lead-lag relationship between the aggregate economy output and construction flows in Sudan. The set of examined data should cover a long period of time in order to arrive at reliable conclusions. Indeed, the secession of Southern Sudan has changed the political and socio-economic setup. Therefore, the subject study only investigates the relation between the economy and construction sector prior to the split of the country into two independent nations. Yet, it is believed that the conclusions of the study will be helpful for both countries to plan for the development of their economies and construction sectors. This will call for similar research in the future to investigate whether the secession has changed the causality relationship between the economy and the construction and the magnitude of this relationship.

5. Methodology

Two analytical tools, namely the input-output analysis and the Granger causality test, are commonly applied in econometrics to investigate the relationship between two variables. The input-output analysis [24] is applied in research for the purpose of identifying the interdependence of production and consumption in an economy. It demonstrates the interrelations among different sectors of the economy where goods and services produced by one sector are consumed as intermediate goods by other sectors. The method measures the strength of backward and forward linkages of each sector in the economy. On the other hand, the Granger causality test examines the lead lag relationship between two variables showing the capability of each variable in predicting the future performance of the other.

Researchers have employed either the input analysis or the Granger causality test to investigate the relation between the construction output and the output of other sectors of the economy. Some researchers applied the input-output (IO) analysis to examine the relation between the construction sector and its counterparts in the economy [25-30], while others adopted the Granger causality test [12-13, 15-17]. The application of the IO analysis seems to be limited to developed countries where all the information needed for the analysis is available. Rameezdeen et al [29] noted that with the exception of very few countries (i.e., Sri Lanka) the method is marginally applied in developing countries (DCs). The IO method is not suitable for DCs due to the lack or scarcity of information needed to carry out the analysis.

The application of input-output analysis to the economic context of the Sudan is hindered by the lack of relevant information required for the analysis. Thus, the Granger causality appears to be more appropriate for studying the relation between the construction sector and other sectors of the economy in the Sudan. Then, the study has employed the Johansen co-integration test to determine the long run relationship between construction output and GDP in a form of a mathematical equation. The study employs data pertaining to the performance of the entire economy - (GDP) - and the output of the construction sector in Sudan during 1982-2009. The data is limited to the period prior to the secession of Southern Sudan as the inclusion of post-secession data in the analysis will probably affect the results and will not provide the long-term relationship between the two variables. However, it would be of great interest to examine the effects of splitting the country into two independent nations on the relation between construction flows and economic performance in both countries.

6. Data Analysis

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another [31]. A time series X is said to Granger-cause Y if the past values of X provide statistically significant information about future values of Y. The granger causality test is run under the null hypothesis H_0: X does not cause Y according to the

following equation:

$$Y_t = \sum_{i=1}^{n} \propto_{0i} X_{t-i} + \sum_{i=1}^{n} \beta_{0i} Y_{t-i} + \varepsilon_t$$

The test results imply that X is granger-causing Y if $\propto_{0i} \neq 0$ in the equation above.

Testing the existence of granger causality essentially requires the use of stationary time series data. The unit root test can be run to test whether a time-series data is stationary or non-stationary. For the purpose of the analysis, the unit roots is performed using Dickey-Fuller (DF), augmented Dickey-Fuller (ADF) tests [13] or Phillips-Perron (PP) [32]. The Dickey–Fuller test [33] explores whether a unit root is present in an autoregressive model by testing the null hypothesis (H_0: $\delta = 0$) which implies that the time series contains a unit root test. The null hypothesis is tests using the following equation:

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t$$

The augmented Dickey-Fuller test (ADF) is an extension of the Dickey–Fuller (DF) test, which removes all the structural effects (autocorrelation) in the time series and then tests for the existence of unit roots using the same procedure.

The ADF test is based on the following formula:

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \alpha_2 Y_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta Y_{t-1} + \varepsilon_t$$

The Phillips–Perron (PP) test [32] is another method for unit root test that tests the null hypothesis that a time series is integrated of order 1.

7. Results

7.1 Unit Root Test Results

As a pre-requisite for running the Granger causality test, the data set has been processed to examine the existence of unit roots. All the data series about the entire economy output were subject to the unit root test to assess

whether it is stationary or not. The unit root test was applied on actual data. The study employs the ADF and PP tests to test the null hypothesis of unit root existence at 1%, 5% and 10% levels of significance. The results of the unit root test are illustrated in (Table 1) which presents the test statistics of the actual data of the total GDP assuming the existence and non-existence of time trends. These values are compared to the critical values presented in (Table 2) to determine the significance of the results obtained. The test was run on the data in their first difference (with one lag) as well.

The results of the unit root test indicate that the data series is stationary. According to the ADF test results, the data of total GDP (Y) were found to be stationary in their level form. The PP test was applied as well to confirm the results of the ADF test. The data series are found to be stationary since that the null hypothesis of unit root with and without time trend cannot be rejected at all levels of significance and with consideration to the critical values (Table 2). For example, the correlation at 1% level of significance for ***Level[a] (no trend)*** is 6.666 (critical value -3.6959) indicating that the null hypothesis cannot be rejected and thus the data is stationary; this applies to the rest of the tested data.

Table 1: Unit root test results

Variable	Level[a]	In 1st Difference[a]	PP Test[a]	Level[a]	In 1st Difference[a]	PP Test[a]
	No Trend	With Trend	No Trend	No Trend	With Trend	No Trend
TOTAL GDP	6.666***	0.3659	-1.455	-4.069**	-1.975	-5.549***

*[a] Figures marked with ***, ** and * indicate correlation is significant at the 0.01, 0.05 and 0.1 level respectively*

Table 2: Mackinnon and Phillips–Perron critical values for unit root tests

Level of Sig.	Level[a]		In 1st Difference[a]		PP Test[a]	
	No Trend	With Trend	No Trend	With Trend	No Trend	With Trend
1%	-3.6959	-4.3382	-3.7204	-4.3738	-3.7076	-4.3552
5%	-2.9750	-3.5867	-2.9850	-3.6027	-2.9798	-3.5943
10%	-2.6265	-3.2279	-2.6318	-3.2367	-2.6290	-3.2321

Source: Mackinnon [34]

7.2 Granger Causality Test Results

Following the test for unit roots, all the data series were subject to the Granger causality test to examine the causality relationship between the construction flows (X) and the total output of the economy (Y) using annual data from 1982 to 2009. The test is applied to investigate whether the information about construction flows is capable of predicting the future output of the Sudanese economy. The Granger causality test consisted of estimating the following equations:

$$Y_t = \sum_{i=1}^{n} \propto_{0i} X_{t-i} + \sum_{i=1}^{n} \beta_{0i} Y_{t-i} + \varepsilon_{(y)t}$$

$$X_t = \sum_{i=1}^{n} \propto_{ni} Y_{t-i} + \sum_{i=1}^{n} \beta_{0i} X_{t-i} + \varepsilon_{(x)t}$$

The first equation implies that construction *(X)* granger causes economic output provided that $\propto_{0i} \neq 0$ in. While in the second equation, economic output is Granger-causing construction *(X)* if $\propto_{ni} \neq 0$. If both events occur, then a feedback exists. In other words, if either $\propto_{0i}$or $\propto_{ni}$ is statically significant, a uni-directional causality exists. Whereas, if both $\propto_{0i}$ and $\propto_{ni}$ are found to be statically significant, then a bi-directional causality runs.

According to the data on the performance of the Sudanese economy and based on the equations above, F statistics are calculated under the null hypothesis that the coefficients $\propto_{0i}$ and $\propto_{ni}$ are equal to zero. The null hypothesis is rejected if the *F* statistics exceeds the critical values. Alternatively, the null hypothesis will be rejected in the *p* value is less than 0.01, 0.05, 0.1 for the 1%, 5% and 10% levels of significance respectively. Table 3 below reports the *F* statistics and the *p* values as derived from the Granger causality test performed.

Table 3: Granger Causality Test results

Null Hypothesis:	F-Statistic[a, b]	Probability[b]	Flow of Causality
X does not Granger Cause Y	0.42431	0.52098	Y → X
Y does not Granger Cause X	9.63818***	0.00483***	

[a] The null hypothesis of no causality is rejected if the F statistics exceeds the critical values 7.721, 4.2252 and 2.90913 at the 1%, 5% and 10% significance levels respectively.

*[b] Figures marked with ***, ** and * indicate the rejection of null hypothesis at the 1%, 5% and 10% levels of significance respectively*

According to the F statistics, the hypothesis of no causality running from construction flows to GDP is not statistically rejected. However, the hypothesis of no causality from GDP to construction flows is statistically rejected implying that aggregate economy leads construction flows. Thus, the construction flows appear to be led by the aggregate economy and not vice versa.

The results of the Granger causality test have demonstrated the nature of the relationship between the output of the construction sector and the aggregate output of the economy in the Sudan. The results reveal that the construction sector does not lead-lag the growth of the economy. On contrary, the results suggest that the expansion of construction activities is preceded by the economic output not vice versa. As a result, it is expected that any increase or decrease in the output of GDP will be felt within the construction sector. This conclusion implies the importance of strategic policies towards economic growth and their implications on the growth of the construction sector.

7.3 Johansen Co-integration test

Johansen test [35] and [36] is a procedure for testing co-integration of several time series of the first lag order *I (1*). Unlike the Engle–Granger test, which is based on the DF and ADF tests, Johansen's test permits more than one co-integration relationship, thus is more generally applicable [37], [38] and [39]. This test has been widely applied in econometrics to examine the co-integration between two different variables [39] and [40]. The test can be applied to examine the long-run equilibrium between the construction sector output and the output of the entire economy as well [15] and [17]. Testing for co-integration is a way of testing the long-term relatedness between time series, whereas Granger causality refers to short run forecastability. Johansen co-integration test has been applied on data pertaining to the aggregate output of the Sudanese economy during 1982-2009. The test was run for the purpose of deriving equations for the long run equilibrium between construction flows and total GDP in the Sudan.

Table 4 reports the results for the co-integration test based on Johansen co-integration test. The Likelihood ratio (L.R.) test indicates two co-integration equation(s) at 5% significance level. Based on the normalized co-integration

coefficients (Table 5), the co-integration equation can be written as follow:

$$X - 0.069451\,Y + 446.7731$$

where: X Construction output; Y: GDP

Table 4: Co-integration test results

Eigenvalue	Likelihood Ratio	5% Critical Value	1% Critical Value	Hypothesized No. of CE(s)
0.530224	25.07619	15.41	20.04	None **
0.18858	5.433204	3.76	6.65	At most 1 *

**(**) denotes rejection of the hypothesis at 5% (1%) significance level*

Table 5: Normalized co-integration coefficients

X05	X14	C
1	-0.069451	446.7731
	(-0.02156)	
Log likelihood	-351.7961	

8. Conclusions

This article demonstrates the causality relationship between the output of the construction sector and the output the economy as a whole in the Sudan employing data pertaining to the real GDP components of the Sudan from 1982 to 2009 in the period prior to the split of the country into two separate nations. The Granger causality test was employed to examine the causality relationship between construction flows and the output of aggregate economy (GDP). The test results generally suggest that the expansion of construction activities is preceded by the economic output. These results suggest that the construction sector is growth-dependent and not growth-initiating implying that aggregate economy leads construction flows. This conclusion comes in conformity with the findings of similar researches in some countries and enhances the debate about the lead-lag relationship between construction output and aggregate economy. Besides, the Johansen co-integration test was employed to derive the equation demonstrating the long-run equilibrium between construction flows and total GDP in the Sudan.

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