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## THE ASYMMETRIC IMPACT OF TRADE OPENNESS ON INFLATION IN SUDAN



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### ABSTRACT

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This study examines the asymmetric impact of openness on inflation in Sudan from 1970 to 2018. This study is distinguished from previous studies applied in Sudan because it employed the trade Globalization Index to measure openness instead of the traditional index. The data were collected from the Central Bank of Sudan and the KOF Swiss Economic Institute website. The nonlinear auto-regressive distributive lag (NARDL) was also employed to examine the asymmetric impact of openness on inflation in Sudan. The results showed that the positive shocks in the openness in the short- and long-terms increased the inflation rate. The negative shocks in the openness in the short term decreased the inflation rate. However, the negative shocks in openness in the long-term did not have an effect on inflation rate. The study recommends a focus on production for self-sufficiency and exports to reduce the inflation rate. In addition, policymakers in Sudan should implement more policies to support openness and control inflation.

**Contribution/Originality:** This study contributes to the existing previous studies applied in Sudan in the sense that it employed the trade Globalization Index to measure openness instead of the traditional index. Additionally, this is the first study in which the NARDL model is used to analyze the relationship between openness and inflation in Sudan.

## 1. INTRODUCTION

Inflation is one of the most difficult economic problems that many countries suffer from. It affects the production and distribution of economic resources and the state's foreign relations. Both internal and external factors interact to influence the rate of inflation, and it is dependent on the economic development of each country and the extent of openness worldwide. Some countries lack industrial base and production capacity. Therefore, they depend on borrowing to meet their expenses, so an increase in spending does not lead to an increase in production, but it would be reflected in the general level of prices. Because of this, the value of the national currency declines, its ability to set out future planning efficiently weakens and the economic sectors are unwilling to produce in the long-term. Moreover, the impact is also reflected in the balance of payments and foreign transactions indicating a negative impact on economic growth. The damage of inflation to society is reflected in the high level of prices and, therefore, individuals need more money to meet their daily expenses, which, in turn, leads to higher costs of living

and higher inflation rates. This development discourages saving and reduces investment, and at this stage, most investments will shift from production to durable assets.

For policymakers, inflation has become one of the most critical issues creating economic instability that could adversely influence economic growth. However, the role of macroeconomic policies in developing countries is to maintain stability and non-inflationary economic growth (Jafari, Ghaderi, Hosseinzadeh, & Nademi, 2012). According to Afzal, Malik, Butt, and Fatima (2013), there are two theories on the impact of openness of inflation. First, the new growth theory hypothesis: the expansion of openness leads to a decrease in the inflation rate. Second, the cost-push hypothesis: the expansion of openness leads to an increase in inflation. Previous studies differed on the relationship between inflation and openness. According to Romer (1993), Alfaro (2005), Gruben and McLeod (2004) and Afzal et al. (2013) inflation tends to decline with more openness. On the other hand, Kouton (2018), Sahu and Sharma (2018), Ajaz, Nain, and Kamaiah (2016), Kurihara (2013) and Abbaspour, Fatahi, and Nazifi (2011) indicated that inflation had a tendency to rise with more openness.

In general, Sudan's economy does not have a good industrial base and thus lacks the ability to compete in production in the global market. This has led to resorting to imports to meet the needs of domestic consumption and foreign debts to finance investments. The experience showed a high inflation rate compared with other macroeconomic indicators, such as exchange rate, poverty rate, negative balance of payments and unemployment rate. The purpose of this study, practically and theoretically, is to clarify the impact of the positive and negative shocks to openness (trade Globalization Index) on inflation in Sudan.

All studies that dealt with the relationship between inflation and other variables in Sudan did not address the effect of openness on inflation, such as those by Yousif and Musa (2018) and Darbo and Nakumuryango (2019). There were also some studies conducted in sub-Sahara African countries, such as those by Ekpof and Effiong (2017), Lin, Mei, Wang, and Yao (2017) and Syed (2012) whose findings revealed that there is a positive coefficient between openness and inflation.

Therefore, the main objective of this study is to fill the gap in Sudanese studies and add new knowledge to recent African and international studies through the investigation of the asymmetric impact of openness on inflation.

The study period from 1970 to 2018 was chosen because it covers all Sudanese economic conditions and economic fluctuations. The researcher considers 2019 to be the beginning of the temporary government period and excluded it from the study. The data were collected from the Central Bank of Sudan and the KOF Swiss Economic Institute website. The nonlinear autoregressive distributive lag (NARDL) was also employed to investigate the asymmetric impact of openness on inflation, and the hypothesis assumed there was an asymmetric impact of openness on inflation in Sudan between 1970 and 2018.

The results of the NARDL approach revealed that the positive shocks in the openness in the short- and long-terms increased the inflation rate. The negative shocks in the openness in the short-term decreased the inflation rate. However, the negative shocks in the openness in the long-term did not have an effect on inflation rate. To increase the positive impact of openness, it is necessary to rely on an industrial production base in addition to policies that encourage domestic and foreign investment in production and industries and the use of modern technology in production.

## 2. LITERATURE REVIEW

Researchers have measured the asymmetric impact of openness on inflation in different ways. Kouton (2018) and Jafari et al. (2012) measured openness using the KOF Index, and others were measured using traditional indexes (exports and imports). Some studies found that the impact of openness was positive on inflation and some found it to be negative. The literature review can be viewed as follows:

The study by Yousif and Musa (2018) used the generalized method of moments (GMM) to estimate the model.

He found that gross domestic product (GDP), unemployment rate and government expenditure all had negative impacts on inflation rate. Additionally, positive effects were found on inflation and exchange rates, money supply and the consumer price index.

Bhat and Sharma (2020) employed the nonlinear autoregressive distributed lag (NARDL) technique for the period from 1970 to 2015. They found that the positive coefficient of economic openness on inflation in the long-term was insignificant, and these results refuted those found by (Romer, 1993), while the negative coefficient of economic openness on inflation in the long-term was statistically significant.

Mukhtar, Jehan, and Bilquees (2019) applied the NARDL technique for the period from 1972 to 2016. They revealed that trade openness and inflation were symmetrically and positively related in the long-term, while the relationship between trade openness and inflation was asymmetrical and optimistic in the short-term. Therefore, the study refuted Romer's hypothesis.

Darbo and Nakumuryango (2019) employed the vector error correction model (VECM) for monthly data from January 2011 to January 2017. They found that the oil prices showed a negative impact on inflation, while money supply, credit to the private sector and nominal effective exchange rate indicated positive impacts in the long-term.

Kouton (2018) also employed the NARDL model. The results revealed asymmetries in the relationship between openness and inflation in the Côte d'Ivoire in both the short and long terms. Inflation increased strongly in the long-term only to decline rather than increase in the openness. The asymmetric impact of transparency on inflation is unique in the short-term. However, higher values of openness found positive and important impacts of openness on inflation. The inflation effect is negative for median values of transparency. For higher rates of transparency, the impact on inflation was positive but non-significant for high value of openness.

Sahu and Sharma (2018) used the NARDL bounds testing approach. They found there was a positive relationship between openness and inflation both in the long- and short-terms and, therefore, refuted Romer's hypothesis. Lin et al. (2017) employed panel data from sub-Saharan Africa. They found that an increase in trade openness restricts inflation. Ekpof and Effiong (2017) applied standard panel data techniques to annual data from 1990 to 2015 for 37 African countries. They found that the impact of monetary policy on economic growth and inflation increased and decreased, respectively. Ajaz et al. (2016) employed the NARDL technique and their results showed the asymmetrical relationship between openness and inflation in the short- and long-terms. In general, there was a weak positive relationship between inflation and openness, but this result was refuted by Romer (1993).

Yiheiyis (2013) used panel data from African countries. He found that increased openness was the correlation scaled with higher inflation to sustain constant variables, such as the restriction of food and level of economic development, which were found to be significant co-determinants. Afzal et al. (2013) used the ARDL approach and their results showed a positive relationship between openness and inflation in the long-term and a negative relationship in the short-term. Kurihara (2013) studied Asian and OECD countries and employed the panel data technique. He found that there was a positive relationship between openness and inflation. Moreover, the relationship between them was assumed to be stronger in Asian countries. Jafari et al. (2012) also employed the panel data approach. The economic openness was measured by the traditional and the Globalization Index. They found that the relationship between trade openness (the traditional index) and inflation was positive. On the other hand, the Globalization Index (KOF index) indicated that higher economic globalization reduced inflation in developed and developing countries, and therefore, it showed that the KOF index was wider and more comprehensive when measuring economic openness.

Abbaspour et al. (2011) used a quantile regression analysis for period from 1942 to 2008. Their results indicated that the trade openness had a positive impact on inflation if inflation was higher, but no impact when inflation was lower. Granato, Lo, and Wong (2007) used the data collected from 15 developed countries. Their study found a positive relationship between inflation and economic openness.

Alfaro (2005) employed panel data for the period from 1973 to 1998. He found that openness was not a factor in

restricted inflation in the short-term. Gruben and McLeod (2004) employed the dynamic panel approach and they found a negative relationship between trade openness and inflation.

### 3 MATERIALS AND METHODS

#### 3.1. Data Sources

The data for the study was collected from the Central Bank of Sudan website (CBS, 2019) and the KOF Swiss Economic Institute website (Gygli, Haelg, Potrafke, & Sturm, 2019) from 1970 to 2018. The selection of this period was due to the availability of data. The inflation rate was measured by the Consumer Price Index. As a measure for openness, the trade Globalization Index was employed, which is a larger measure for trade globalization that was developed by the KOF Swiss Economic Institute. This measure was adopted because the KOF Globalization Index is a better proxy for measuring economic openness (Jafari et al., 2012; Kouton, 2018). Throughout the analytical framework, other variables were often used which played the role of control over variables. The selection of such variables based on the literature review was related to the impact of openness on inflation. Some of the variables were real GDP growth rate, money supply growth rate and nominal exchange rate.

All variables are measured in pounds except the trade Globalization index, which is measured in points. The measurement unit is standardized by dividing by the standard deviation of the dependent variable.

#### 3.2. Model Specification

The literature review of studies by Ada, Oyeronke, Odunayo, Okoruwa, & Obi-Egbedi (2014), Atabay (2016), Bhat & Sharma (2020), Ekpof & Effiong (2017) and Lin et al. (2017) defined the model as follows:

$$inf = f(KOF, EX, GRO, M)$$

Inf: inflation rate.

KOF: trade Globalization Index for the measure of openness.

EX: nominal exchange rate.

GRO: real GDP growth rate.

M: money supply growth rate.

### 4. ECONOMETRIC ANALYSIS METHODS

#### 4.1. Descriptive Statistics

Table 1 shows the mean for all variables higher than the median, so the series are positively skewed except for real GDP growth. The standard deviation value indicates that the series is between the maximum and minimum values except for the KOF index. The skewness is lower than the kurtosis coefficient.

#### 4.2. Unit Root Test

The augmented Dickey–Fuller (ADF), Phillips–Perron unit root, Kapetanios, Shin and Andy Snell (KSS), non-linear unit root and Guris unit root tests were used to examine the stationarity or non-stationarity of the variables. The results are shown in Tables 2 to 5.

Table 1. Descriptive statistics.

	INF	GRO	EX	KOF	M
Mean	0.858241	0.105920	0.041337	0.808541	0.939813
Median	0.504110	0.129618	0.005161	0.731557	0.736706
Maximum	4.336304	0.339434	0.220336	1.046208	4.030271
Minimum	-0.023891	-0.154223	7.17E-05	0.584147	0.000000
Std. Dev.	0.964288	0.116347	0.057181	0.156573	0.733086
Skewness	1.930457	-0.606965	1.586626	0.354407	1.940430
Kurtosis	6.405737	2.796627	4.853223	1.489012	8.240743
Sum	42.05379	5.190076	2.025509	39.61853	46.05084
Sum Sq. Dev.	44.63286	0.649763	0.156945	1.176726	25.79591
Observations	49	49	49	49	49

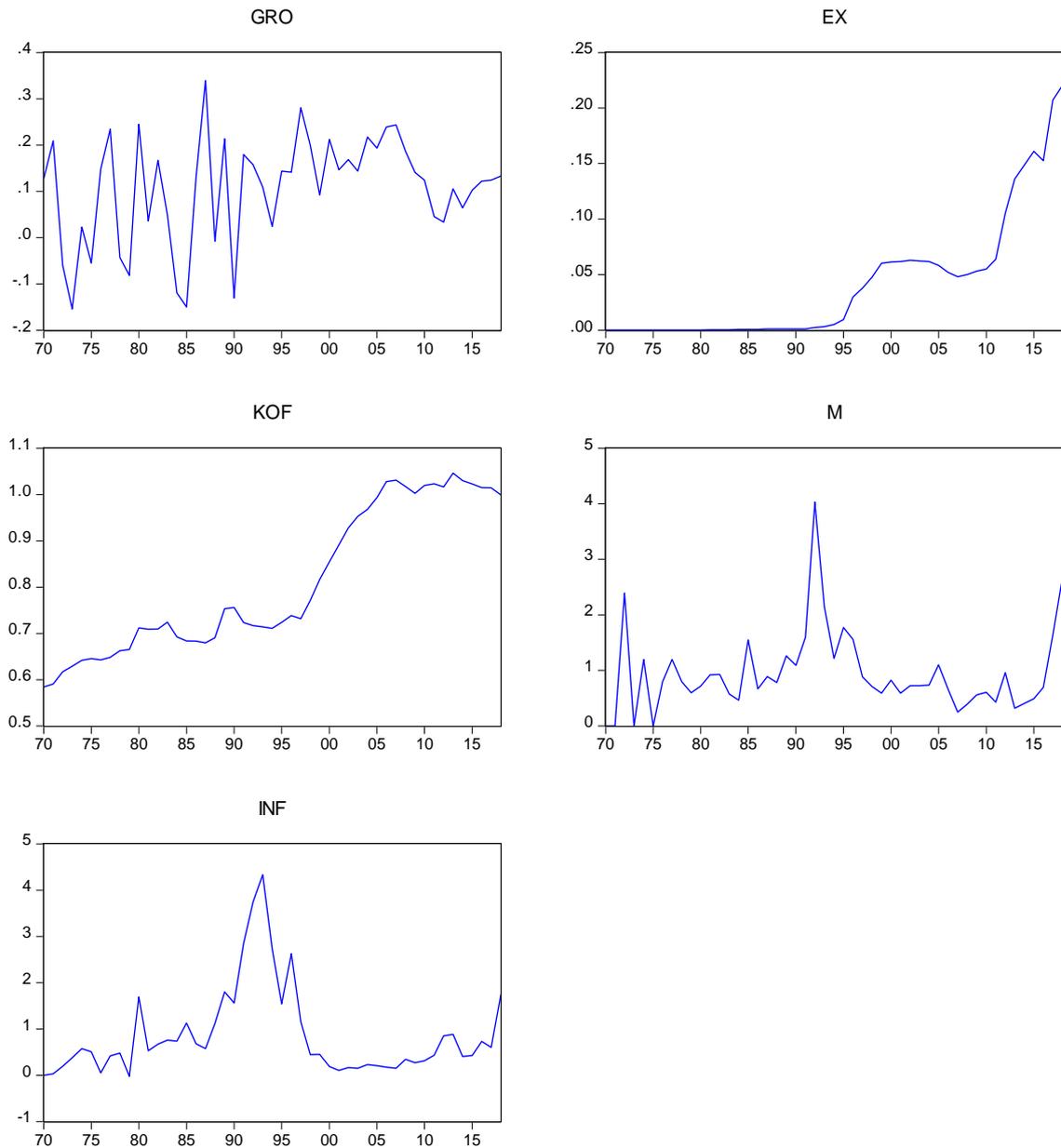


Figure 1. The trend of variables for the period 1970-2018.

Table 2. Augmented Dickey-Fuller Unit Root Test.

UNIT ROOT TEST RESULTS TABLE (ADF)						
Null Hypothesis: the variable has a unit root						
At Level						
		INF	KOF	EX	M	GRO
With Constant	t-Statistic	-2.3404	-0.9528	3.4332	-4.5586	-5.7262
	Prob.	0.1639	0.7623	1.0000	0.0006	0.0000
		n0	n0	n0	***	***
With Constant & Trend	t-Statistic	-2.3155	-1.6524	1.0439	-4.5008	-6.2216
	Prob.	0.4178	0.7564	0.9999	0.0040	0.0000
		n0	n0	n0	***	***
Without Constant & Trend	t-Statistic	-1.4458	1.5807	4.6396	-2.0265	-2.5903
	Prob.	0.1366	0.9704	1.0000	0.0420	0.0107
		n0	n0	n0	**	**
At First Difference						
		d(INF)	d(KOF)	d(EX)	d(M)	d(GRO)
With Constant	t-Statistic	-7.5908	-4.7491	-2.5390	-7.2605	-10.6345
	Prob.	0.0000	0.0003	0.1138	0.0000	0.0000
		***	***	n0	***	***
With Constant & Trend	t-Statistic	-7.4937	-4.7136	-3.7994	-7.1955	-10.5268
	Prob.	0.0000	0.0022	0.0267	0.0000	0.0000
		***	***	**	***	***
Without Constant & Trend	t-Statistic	-7.6531	-4.2794	-1.9851	-7.3344	-10.7512
	Prob.	0.0000	0.0001	0.0462	0.0000	0.0000
		***	***	**	***	***

## Notes:

a: (\*)Significant at the 10% level; (\*\*)Significant at the 5% level; (\*\*\*) Significant at the 1% level, and (no) not significant.

b: Lag length based on SIC.

c: Probability based on MacKinnon (1996) one-sided p-values.

Table 2 shows that all variables were stationary at the first difference.

Table 3. Phillips-Perron Unit Root Test.

Unit Root Test Results Table (PP)						
Null Hypothesis: the variable has a unit root						
At Level						
		INF	KOF	EX	M	GRO
With Constant	t-Statistic	-2.3786	-0.8436	3.4332	-4.5723	-5.7262
	Prob.	0.1530	0.7973	1.0000	0.0006	0.0000
		n0	n0	n0	***	***
With Constant & Trend	t-Statistic	-2.3525	-1.6594	0.9149	-4.5164	-6.1876
	Prob.	0.3988	0.7538	0.9998	0.0038	0.0000
		n0	n0	n0	***	***
Without Constant & Trend	t-Statistic	-1.3923	1.9820	4.6396	-1.6168	-3.6658
	Prob.	0.1503	0.9876	1.0000	0.0992	0.0005
		n0	n0	n0	*	***
At First Difference						
		d(INF)	d(KOF)	d(EX)	d(M)	d(GRO)
With Constant	t-Statistic	-7.6129	-4.8021	-4.8126	-11.9469	-30.2700
	Prob.	0.0000	0.0003	0.0003	0.0000	0.0001
		***	***	***	***	***
With Constant & Trend	t-Statistic	-7.5124	-4.7721	-5.7094	-11.7954	-30.6333
	Prob.	0.0000	0.0019	0.0001	0.0000	0.0000
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-7.6764	-4.3746	-4.2722	-12.0051	-31.8675
	Prob.	0.0000	0.0000	0.0001	0.0000	0.0000
		***	***	***	***	***

## Notes:

a: (\*)Significant at the 10% level; (\*\*)Significant at the 5% level; (\*\*\*) Significant at the 1% level, and (no) not significant.

b: Lag Length based on SIC.

c: Probability based on MacKinnon (1996) one-sided p-values.

Table 3 shows that all variables were stationary at the first difference.

**Table 4.** Kapetanios, Shin & Snell Non-linear Unit Root Test Results for Reset Testing Variables.

<b>I</b>	<b>Estimate</b>	<b>t-statistics</b>	<b>p-value</b>
INF	0.036556	5.416080	0.0000
Kof	0.029247	3.206966	0.0075
Ex	3.605698	2.801372	0.0068
GRO	13.70238	9.183459	0.0000
M	0.052250	7.963251	0.0000
KSS critical value			
1%		-3.55	
5%		-2.95	
10%		-2.66	

Table 4 shows that the variables are non-linear-stationary. This was done by comparing the t-statistics in the KSS table with the KSS critical values (Güriş, 2017).

**Table 5.** Guris Unit Root Test.

<b>Variable</b>	<b>Lags</b>	<b>Test Stat</b>
INF	4	10.21
KOF	4	7.98
EX	4	8.23
GRO	4	15.58
M	4	9.66
Critical Values k=4		
1%		13.38
5%		9.56
10%		7.92

Table 5 shows that the test stat (Güriş, 2017) is greater than the critical values at the 10% and 5% levels. Therefore, the series are non-linear-stationary, and the ARDL and NARDL models can be employed in the analysis.

#### 4.3. NARDL Method

This study used the asymmetric ARDL model to check the short- and long-term asymmetries between the dependent and independent variables. The model was developed by Shin, Yu, and Greenwood-Nimmo (2014) to analyze asymmetry in the variables of interest while maintaining all the advantages of the ARDL approach. The non-linear model allows for the delineation of asymmetric effects into positive and negative shocks in cases where the partial sums of these shifts are unbalanced. In the case of the NARDL model, positive changes can have a different effect on the dependent variable than negative changes. However, the model cannot be used for second-order integral variables (Cheah, Yiew, & Ng, 2017; Kassi et al., 2019).

First, the ARDL model is specified as follows:

$$\Delta(INF) = \alpha_0 + \sum_{i=1}^n \alpha_1 \Delta INF_{t-i} + \sum_{i=1}^m \alpha_2 \Delta KOF_{t-i} + \sum_{t=1}^s \alpha_3 \Delta EX_{t=i} + \sum_{t=1}^k \alpha_4 \Delta GRO_{t-i} + \sum_{t=1}^q \alpha_5 \Delta M_{t-i} + \alpha_6 INF_{t-i} + \alpha_7 KOF_{t-i} + \alpha_8 EX_{t-i} + \alpha_9 RGDP_{t-i} + \alpha_{10} M_{t-i} + e_t$$

Second, the NARDL model is specified as follows:

$$\begin{aligned} \Delta(INF) = & \alpha_0 + \sum_{i=1}^m \alpha_1 \Delta INF_{t-i} + \sum_{i=1}^m \alpha_2^+ \Delta KOF_{t-i}^+ + \sum_{i=1}^m \alpha_2^- \Delta KOF_{t-i}^- + \sum_{t=1}^s \alpha_4 \Delta EX_{t=i} + \sum_{t=1}^k \alpha_5 \Delta GRO_{t-i} \\ & + \sum_{i=1}^q \alpha_6 \Delta M_{t-i} + \alpha_7 INF_{t-i} + \alpha_8^+ KOF_{t-i}^+ + \alpha_8^- KOF_{t-i}^- + \alpha_{10} EX_{t-i} + \alpha_{11} GRO_{t-i} \\ & + \alpha_{12} M_{t-i} + e_t \end{aligned}$$

To assess long-term asymmetric effects, the Wald test was performed in the following null hypothesis versus the alternative hypothesis of symmetry:

$$H_0: \alpha_8^+ = \alpha_8^-$$

$$H_1: \alpha_8^+ \neq \alpha_8^-$$

#### 4.4. Estimation of Asymmetric NARDL Results

The results in Table 6 illustrate that the value of the INF (-1) coefficient was negative and statistically significant.

Table 6. Estimation of Asymmetric NARDL results.

Variable	Coefficient	Std. Error	t-statistics	p-value
C	-0.87787	-0.24653	-3.56085	0.0014
INF(-1)*	-0.80979	0.140011	-5.78375	0.0000
KOF_POS(-1)	3.360678	1.527771	2.199727	0.0366
KOF_NEG(-1)	2.569795	5.129882	0.500946	0.6205
EX(-1)	-12.3181	4.514886	-2.72834	0.0111
GRO(-1)	-4.58389	2.086013	-2.19744	0.0367
M(-1)	1.354944	0.203144	6.669884	0.0000
D(KOF_POS)	15.94237	6.344912	2.512623	0.0183
D(KOF_NEG)	-43.1881	12.06973	-3.57822	0.0013
D(EX)	7.612898	6.765003	1.125336	0.2704
D(EX(-1))	1.535886	8.490426	0.180896	0.8578
D(EX(-2))	-4.76822	10.67053	-0.44686	0.6585
D(EX(-3))	24.22338	13.4235	1.804551	0.0823
D(GRO)	-0.34828	0.694283	-0.50163	0.6200
D(GRO(-1))	3.133446	1.507081	2.079148	0.0472
D(GRO(-2))	1.554075	1.025739	1.515079	0.1414
D(GRO(-3))	1.388306	0.706907	1.963915	0.0599
D(M)	0.555142	0.136027	4.081113	0.0004

#### 4.5. Estimation of Long-term Coefficients

Table 7 and Figure A indicate that an increase in openness has a coefficient of 4.15 and it is statistically significant. Consequently, in the long-term, a 1% increase in openness will lead to a 4.15% increase in the inflation rate, supporting the previous findings by Mukhtar et al. (2019); Kouton (2018); Sahu and Sharma (2018); Ekpof and Effiong (2017); Ajaz et al. (2016); Afzal et al. (2013); Yiheyis (2013); Kurihara (2013); Granato et al. (2007) and Abbaspour et al. (2011). It is contradicted by Romer's hypothesis that inflation would decrease with openness (Alfaro, 2005; Gruben and McLeod, 2004); Bhat and Sharma, 2020; Lin et al., 2017 and Afzal et al., 2013). The positive relationship indicates that the Sudan economy depends on imports, especially luxury goods. The KOF negative coefficient does not significantly affect inflation in the long-term, however, it contradicts Yousif and Musa (2018) and Jafari et al. (2012). A decrease in exchange rate has a coefficient of 15.21 and is statistically significant. A 1% decrease in exchange rate will lead to a 15.21% increase in inflation rate, which contradicts Yousif and Musa

(2018). An increase in the money supply growth rate has a coefficient of 1.67 and is statistically significant. A 1% increase in the growth rate money supply will lead to a 1.67% increase in inflation rate, supporting the findings by Yousif and Musa (2018) and Darbo and Nakumuryango (2019). A decrease in RGDP growth rate has a coefficient of 5.66 and is statistically significant. A 1% decrease in growth rate RGDP will lead to a 5.66% increase in the inflation rate, supporting the findings by Yousif and Musa (2018).

Table 7. Estimation of Long-term Coefficients.

Variable	Coefficient	Std. Error	t-statistics	p-value
KOF_POS	4.150064	2.166205	1.915822	0.066
KOF_NEG	3.173411	6.581228	0.482191	0.6336
EX	-15.2115	5.22412	-2.91179	0.0071
GRO	-5.6606	2.772072	-2.04201	0.051
M	1.673205	0.240246	6.964558	0.0000

Note:  $EC = INF - (4.1508 * KOF\_POS + 3.2325 * KOF\_NEG - 15.1781 * EX + 1.674 * M - 5.6481 * GRO)$ .

#### 4.6. Short-term Error Correction

The short-term results in Table 8 and Figure B show that the value of the ECM (-1) coefficient was negative and statistically significant. This shows that any shock on inflation will be corrected within the next year at 81%. It is considered a very high effect and supports the findings by Sahu and Sharma (2018) and Ajaz et al. (2016). The KOF positive coefficient has statistical significance at the 0.01 level; in the short term, a 1% increase in the KOF positive coefficient would increase inflation rate by 15.9%, which contradicts Mukhtar et al. (2019). The KOF negative coefficient has statistical significance at the 0.01 level; in the short term, a 1% increase in the KOF negative coefficient would decrease inflation rate by 43%, supporting the findings by Afzal et al. (2013) and contradicts Alfaro (2005) and Mukhtar et al. (2019). The exchange rate (ex) coefficient does not significantly affect inflation in the short-term, except the exchange rate (-3) coefficient, which has statistical insignificance at the 0.01 level. The money supply growth rate (M) coefficient has statistical significance at the 0.01 level; in the short term, a 1% increase in (M) would increase the inflation rate by 56%. The RGDP growth rate (GRO(-1)) coefficient does not significantly affect inflation in the short-term. The RGDP growth rate (GRO (-2,-3)) coefficient has statistical significance at the 0.01 level in the short term.

Table 8. Estimation of Short-term Coefficients.

Variable	Coefficient	Std. Error	t-statistics	p-value
C	-0.87787	0.12349	-7.10887	0.0000
D(KOF_POS)	15.94237	4.00027	3.985323	0.0005
D(KOF_NEG)	-43.1881	10.50451	-4.11139	0.0003
D(EX)	7.612898	5.441578	1.399024	0.1732
D(EX(-1))	1.535886	5.550154	0.276728	0.7841
D(EX(-2))	-4.76822	9.087411	-0.52471	0.6041
D(EX(-3))	24.22338	8.467582	2.86072	0.0081
D(GRO)	-0.34828	0.496185	-0.70191	0.4887
D(GRO(-1))	3.133446	0.661648	4.735823	0.0001
D(GRO(-2))	1.554075	0.534004	2.910234	0.0072
D(GRO(-3))	1.388306	0.544323	2.55052	0.0167
D(M)	0.555142	0.109699	5.060604	0.0000
CointEq(-1)*	-0.80979	0.098814	-8.19513	0.0000

#### 4.7. Long-Term Asymmetry Test

Table 9 indicates that the null hypothesis of the symmetric relationship is rejected at the 1% significance level. Therefore, there is an asymmetrical relationship between openness and inflation.

Table 9. Long-term Asymmetry Test.

Wald Test			
Coefficient	Std. Error	t-statistics	Std. Error/t-statistics
0.976653	5.042418	0.193687	0.8479
F-statistics:	0.037515	Prob:	0.8479

#### 4.8. Diagnostic and Stability Analysis

Table 10 indicates that the Breusch-Pagan Lagrange multiplier test LM test showed no problem in terms of serial correlation as the p-value is 0.91, which is higher than 0.05. The results of the autoregressive conditional heteroscedasticity (ARCH) test showed no heteroscedasticity as the p-value is 0.37, which is higher than 0.05. The Ramsey RESET test explains the model as valid because the p-value of 0.182 is higher than 0.05. The Jarque-Bera test showed no serial correlation problem since the p-value of 0.53 is higher than 0.05.

Table 10. Diagnostic and Stability Analysis.

Statistics	Estimated Value	Prob
Breusch-Godfrey Serial Correlation LM Test	0.01046	0.9193
ARCH Test	0.808095	0.3738
Ramsey RESET Test	1.874510	0.1827
Jarque-Bera	1.270214	0.52988

#### 4.9. Stability Analysis

Figure 1 indicates the model's stability because the CUSUM and the CUCUM of square are within the 5% critical bounds.

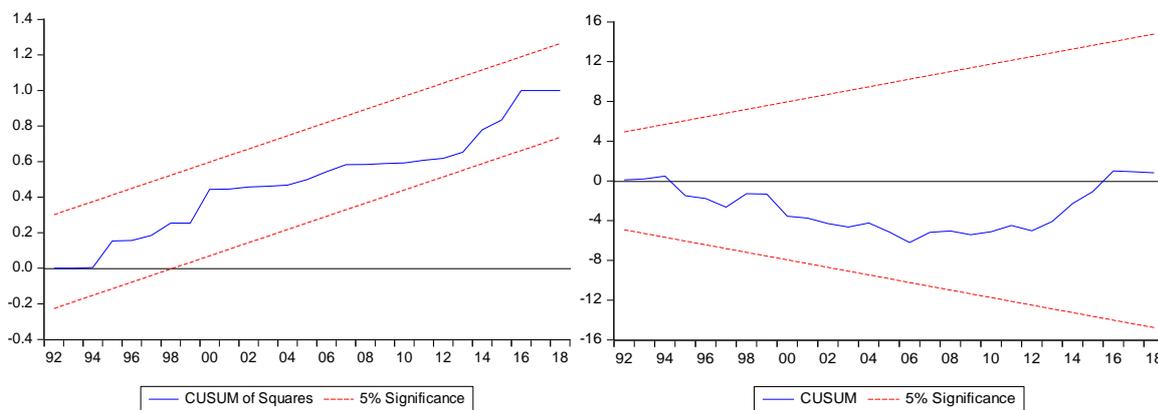


Figure 2. Plot of CUSUM and the CUCUM of square of recursive residual.

## 5. CONCLUSIONS AND POLICY IMPLICATIONS

The results showed that the positive shocks in openness in the short- and long-term increased the inflation rate, which indicates increasing integration with the global economy leading to inflationary pressures. Therefore, this result indicates that the Sudan economy has not properly established an industrial base and therefore lacks the ability to compete in production at a global level. This incompetence has led to dependence on imports to satisfy local consumption and external debt to meet its investment expenditures. In addition, this result refutes Romer's hypothesis. The negative shocks in openness in the short-term decreased the inflation rate. However, the negative shocks in openness in the long-term did not have an effect on the inflation rate. In the short-term, economic openness leads to an increase in the foreign investment flow, which leads to the foreign exchange flows, and in return, a local currency is minted against demand, which creates spurious stability in the short-term. On the contrary, in the long-term, minting leads to an increase in the money supply, which leads to an increase in inflation

with increased openness. In addition, the imported inflation and the marginal propensity to consume of the Sudanese always lean toward imported commodities. To increase the positive impact of openness, it is necessary to rely on an industrial production base in addition to policies that encourage domestic and foreign investment in production and industries and the use of modern technology in production. Thus, economic policymakers and economic researchers will benefit from reading this article.

## 6. RECOMMENDATIONS

This study recommends that further research should be carried out to investigate if there is any change in the relationship between openness and inflation as result of changes in the other variables in the short- and long-term. Policymakers in Sudan should implement more policies that support openness and control inflation and focus on production for self-sufficiency and export to reduce the inflation rate.

## 7. LIMITATION

The study was limited to the period between 1970 and 2018 due to lack of data for 2019 and 2020.

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## APPENDICES

Figure A. Estimation of long-term coefficients.

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(INF)				
Selected Model: ARDL(1, 1, 1, 4, 4, 1)				
Case 3: Unrestricted Constant and No Trend				
Date: 09/05/20 Time: 08:14				
Sample: 1970 2018				
Included observations: 45				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.877873	0.246534	-3.560852	0.0014
INF(-1)*	-0.809790	0.140011	-5.783749	0.0000
KOF_POS(-1)	3.360678	1.527771	2.199727	0.0366
KOF_NEG(-1)	2.569795	5.129882	0.500946	0.6205
EX(-1)	-12.31813	4.514886	-2.728337	0.0111
GRO(-1)	-4.583892	2.086013	-2.197442	0.0367
M(-1)	1.354944	0.203144	6.669884	0.0000
D(KOF_POS)	15.94237	6.344912	2.512623	0.0183
D(KOF_NEG)	-43.18813	12.06973	-3.578219	0.0013
D(EX)	7.612898	6.765003	1.125336	0.2704
D(EX(-1))	1.535886	8.490426	0.180896	0.8578
D(EX(-2))	-4.768222	10.67053	-0.446859	0.6585
D(EX(-3))	24.22338	13.42350	1.804551	0.0823
D(GRO)	-0.348275	0.694283	-0.501633	0.6200
D(GRO(-1))	3.133446	1.507081	2.079148	0.0472
D(GRO(-2))	1.554075	1.025739	1.515079	0.1414
D(GRO(-3))	1.388306	0.706907	1.963915	0.0599
D(M)	0.555142	0.136027	4.081113	0.0004
* P-value incompatible with t-Bounds distribution.				
Levels Equation				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
KOF_POS	4.150064	2.166205	1.915822	0.0660
KOF_NEG	3.173411	6.581228	0.482191	0.6336
EX	-15.21152	5.224120	-2.911787	0.0071
GRO	-5.660596	2.772072	-2.042009	0.0510
M	1.673205	0.240246	6.964558	0.0000
EC = INF - (4.1501*KOF_POS + 3.1734*KOF_NEG -15.2115*EX -5.6606 *GRO + 1.6732*M)				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	9.444399	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68
Finite Sample: n=45				
Actual Sample Size	45			
		10%	2.458	3.647
		5%	2.922	4.268
		1%	4.03	5.598
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)

t-statistic	-5.783749	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.5%	-3.13	-4.46
		1%	-3.43	-4.79

Figure B. Short-term error correction result.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.877873	0.123490	-7.108865	0.0000
D(KOF_POS)	15.94237	4.000270	3.985323	0.0005
D(KOF_NEG)	-43.18813	10.50451	-4.111387	0.0003
D(EX)	7.612898	5.441578	1.399024	0.1732
D(EX(-1))	1.535886	5.550154	0.276728	0.7841
D(EX(-2))	-4.768222	9.087411	-0.524706	0.6041
D(EX(-3))	24.22338	8.467582	2.860720	0.0081
D(GRO)	-0.348275	0.496185	-0.701906	0.4887
D(GRO(-1))	3.133446	0.661648	4.735823	0.0001
D(GRO(-2))	1.554075	0.534004	2.910234	0.0072
D(GRO(-3))	1.388306	0.544323	2.550520	0.0167
D(M)	0.555142	0.109699	5.060604	0.0000
CointEq(-1)*	-0.809790	0.098814	-8.195131	0.0000
R-squared	0.773769	Mean dependent var		0.030316
Adjusted R-squared	0.688933	S.D. dependent var		0.652050
S.E. of regression	0.363671	Akaike info criterion		1.051714
Sum squared resid.	4.232200	Schwarz criterion		1.573639
Log likelihood	-10.66357	Hannan-Quinn criter.		1.246283
F-statistic	9.120702	Durbin-Watson stat		1.945710
Prob(F-statistic)	0.000000			
* p-value incompatible with t-Bounds distribution.				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.444399	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-8.195131	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.5%	-3.13	-4.46
		1%	-3.43	-4.79

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