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RESEARCH PAPER

Inflation's Impact on Sudan Exports 1990-2020: An ARDL Approach

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ABSTRACT

PURPOSE: This study investigates the inflation-export nexus in Sudan over the period 1990-2020.

DESIGN/METHODOLOGY: The study is based on quantitative and qualitative methods, estimating the export function and measuring the impact of its determinants over a prolonged period of time. The Autoregressive Distributed Lag (ARDL) methodology was used to analyse the co-integration.

FINDINGS: The paper presented inflation's negative impact on exports over the period 1990-2020. The long-term results indicated that the most important variable affecting exports is gross domestic product (GDP), followed by inflation. Interestingly, the results indicated that the exchange rate was not significant, in neither the short or long term.

Inflation is significant at the 5% level and has an opposite effect. Its coefficient is -0.33, meaning that an increase in inflation by 1% leads to a decrease in exports by 0.33% in the long term.

The speed of modifying the proposed model towards equilibrium, or the error-correction limit, where the two conditions have been achieved show that it is eminent at the 1% level and takes a negative sign as expected. Its coefficient is -0.459, indicating that the model can correct the error and return to the normal situation within a period estimated (about two years and a month). This means that when exports during the short-term deviate from their equilibrium value, an equivalent of 0.459% of this imbalance can be corrected until it reaches equilibrium in the long-run.

IMPLICATIONS: The study recommends an inflation control policy as a prerequisite for an export development strategy; this overcomes barriers and paves the road for shifting Sudan's economy to productive agendas. Therefore, targeting inflation will contribute to export diversification and strengthen the product's value chain.

The research findings reconsider the weight of export's determinants and will reposition focus to inflation control rather than exchange rate policy.

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ORIGINALITY/VALUE: The paper introduces a new approach in modelling the inflation-export nexus, elaborates on export's determinants and their weights, and recommends guidelines to adapt inflation policy to export development strategy.

KEYWORDS: *Export; Inflation; Sudan economy; ARDL*

INTRODUCTION

Exports play a significant role in economic growth; therefore, increasing exports will help increase aggregate demand, resulting in higher economic growth. As higher economic growth improves the balance of payments, employment, and living standards, governments attempt to remove barriers and encourage export performance. Primarily, export promotion begins with identifying determinants, variables, and their pattern of relationship in the country.

Based on quantitative and qualitative methods, this research investigates the inflation-export nexus in Sudan over the period 1990-2020. The next section reviews the literature and theoretical background. The third section elaborates the methodology and data, while the fourth section discusses empirical results and variables characteristics, concluding with recommendations and policy implications.

LITERATURE REVIEW

Theoretical Background

Many studies have examined the determinants of exports. Hsiao and Hsiao (2006) investigated the relationship among foreign direct investment (FDI), exports, and gross domestic product (GDP) for eight East and Southeast Asian economies. This was done using a Granger causality test, and annual panel data over the period 1986-2004 was analysed. The outcome was that there is bidirectional causality between exports and GDP.

In his research, Xu (2000) used empirical support for the hypothesis that primary exports positively affect economic growth. He utilised a vector auto regression (VAR) approach for 74 countries as a sample over the period 1965-1992, and affirmed that 55 of the 74 countries show positive effects of primary export growth on long-term GDP growth. Kumar's (1998) study focused on the determinants of export performance in developing countries; he confirmed that GDP has a favourable effect on exports.

Using panel data for 75 developing countries, Majeed *et al*., (2006) investigated the determinants of exports over the period 1970-2004. The exports equation was identified with FDI, GDP, GDP growth rate, communication facilities, real effective exchange rate, indirect taxes, and labour force as exogenous variables. The estimation was based on the random effect model; the variables carry significant magnitudes with a correct sign, except for FDI that is insignificant although it has its expected sign. In addition, products of exportation manufactured by labour-intensive industries can improve the export base of any developing country.

Elhiraika and Mbate (2014) empirically explored the long-run determinants of export diversification by estimating a cross-country regression model using a panel of 53 African countries for 1995-2011. The assessment provides sound evidence supporting the importance of per capita income, infrastructure, public investment, human capital, and the institutional framework as significant grounds of export diversification.

Elaborating the wide-range scope of export performance, Babatunde (2012) stated that:

> "there are two main schools of thought when it comes to explaining the performance of exports. While one stresses factors that are external to the individual country (export demand), the other line of thought emphasizes factors that are internal to a particular country (export supply). However, the knowledge of the determinants of export performance is still characterized by a fragmented collection of confusing findings".

It has been recognised that macroeconomic variables, such as exchange rate and inflation, play an important role in influencing the performance of exports. In particular, the exchange rate is an important factor in promoting export growth, diversification, and external competitiveness of goods produced in the country (UNCTAD, 2005). Identically, real exchange devaluation encourages the internal production condition and enhances the competitiveness of the goods, and leads to diversification of exports (Oyejide, 2007; Fugazza, 2004).

Malhotra and Kumari (2016) examined the determinants of export performance of selected Asian economies during 1980-2012. They divided countries into sub-regions namely East Asia, Southeast Asia and South Asia. East Asia includes China, Japan and South Korea; Southeast Asia includes Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam, while South Asia contains Bangladesh, India, Pakistan and Sri Lanka. Using aggregate annual data, an Ordinary Least Square (OLS) approach was used to estimate the impact of various factors on export performance of these Asian economies. Conventional demand and supply factors, such as world demand, real effective exchange rate, production level or capacity and relative prices, were used. The study incorporates the effect of FDI inflows and trade openness on export performance.

In their work, Rahman *et al*. (2019) researched the determinants and issues influencing Bangladeshi textile and clothing (T&C) exports. A dataset was generated and used to estimate the panel gravity model of Bangladeshi T&C export flows to a total of its 40 trade partners over a period of 27 years from 1990 to 2017. The results affirm that GDP, real exchange rate and per capita GDP of the importers appeared to be major determinants of Bangladesh's textile exports. In addition, Bangladesh and World Trade Organization membership have a strong positive significant impact on T&C exports.

Uysal and Mohamoud (2018) studied the determinants of export performance in seven East African countries (Ethiopia, Madagascar, Kenya, Sudan, Mozambique, Tanzania, and Zambia) from 1990 up to 2015. Data were analysed using Stata to perform the econometric analysis technique.

They selected a model showing the relationship between export value and selected variables as a determinant of exports to examine whether it has a positive or negative effect on export performance.

In their research, Kiganda *et al*. (2017) tested exports as inflation's determinant in Kenya. They affirmed the greater influence of domestic exports on inflation.

Empirically, many studies have asserted that exchange rate stability is a significant factor determining export performance (e.g., Biggs, 2007; Fugazza, 2004; Elbadawi and Soto, 1997). As an example, DeRosa and Greene (1991) argued that maintaining realistic exchange rates results in a pronounced increase in the production and export of goods in African countries. In the same way, Elbadawi and Soto (1997) show that real exchange rate depreciation would enhance the incentives for exporting activities and expand the production of exported goods relative to GDP. Purusa and Istiqomah (2018) traced the effect of inflation on exports of five Asian countries; they affirmed a negative and significant effect, whereby the inflation variable has a coefficient value at 3.77E+09. This indicates that each 1% increase in inflation will decrease the volume of exports by US$3.77 billion. The result indicates that a continuous increase in the overall price of goods will decrease exports. Undoubtedly, increased prices will generate competition between a local product and an imported product, which will affect the pricing policy (Kamin and Klau, 2003). Inflation can lead to a boost in the price of the input, meaning a decrease in the productivity of firms (Dritsakis, 2004; Narayan and Smyth, 2009). Subsequently, the high cost of production will reduce the competitiveness of a country compared to other countries (Sinn, 2014).

In their article, Jacob *et al*. (2021) analysed the determinants of Indian exports with special reference to inflation and the exchange rate. The results derived from this study suggest that all variables are statistically significant for influencing export performance, meaning that exchange rate and inflation have a positive impact on export performance.

Sudanese Economy

During its 70 years of national governments, Sudan has had a weak performance in economic indicators. At independence in 1956, Sudan's had a dual economy with a vast traditional sector and a smaller modern one. Economic activity or export performance mutually depend heavily on natural resources: arable land, pasture, minerals, fossil energy, and abundant water. Sudan's economic performance was volatile and dominated by a negative pattern; Ali and Elbadawi (2004) calculated trend growth rate from 1960 to 1998 and found -0.89, 1.27, -0.11, 2.96 and 0.02 for the periods 1960-1973, 1974-1983, 1984-1994, 1995-1998 and 1960-1998, respectively.

Sudan's prime export characteristic is very low diversification whether in destinations or products, with only five products being exported to more than seventeen countries between 1996 and 2013. These products are gum Arabic, sesame seeds, refined oil, cooper waste, and scrap. The EU is the primary market for gum Arabic, MENA for sesame seeds, and China and the rest of Asia for copper waste and scrap. Most refined oil is destined for the "Rest of the World", including

Sub-Saharan Africa (SSA) (World Bank, 2015). The lack of Sudan's product diversification appears when compared to peer countries, as evidenced by its comparatively much higher Herfindahl-Hirschman index. Moreover, the index has increased in recent years, while in many of its comparators it has decreased. All these characteristics put Sudan in the group of Heavily indebted countries (HIPCs) UNDP (2006).

In their study assessing inflation dynamics in Post-Secession Sudan, Darbo and Nakumuryango (2019) noticed that macroeconomic stability in Sudan is affected by several factors. First, a narrow export base, second, quasi-fiscal operations of the government, and third, an unconducive investment climate, failure to deepen reforms by agreeing with the IMF on the 14th Staff Monitored Program (SMP) in 2015, a multiple exchange rate system, sanctions, and ill-targeted subsidies. These vulnerable conditions produced an unfavourable environment for export, this similar result found by Central Bank of Sudan (2010) research defining determinants of inflation in Sudan.

Exports were affected heavily by economic sanctions; partners had been changed after 1997 as shown in Table 1.

Table 1: Export of Sudan by Partner (Percentage of Total Exports)

Partners	1980-89	1990-97	1998-2006	2007-16
Advanced economies	65.0	47.3	48.7	25.9
Emerging markets and developing countries	34.8	52.7	51.3	74.1
European Union	43.3	36.2	29.9	16.0
United States	10.8	4.5	1.0	1.0

Source: AfDB (2018)

METHODOLOGY AND DATA

The analysis covers the period 1990-2020 and is based on reports issued by the Central Bank of Sudan (CBS), Central Statistics Bureau, and Ministry of Finance. To estimate the export function and measure the impact of its determinants in the long and short term, an Autoregressive Distributed Lag (ARDL) methodology was used to analyse the co-integration. This methodology was developed by Pesaran *et al*. (2001) and was known as the Bounds Testing Procedure; it does not require that the basic variables be integrated to the same degree. In addition, this method is used to test the existence of a single long-term relationship between the dependent variable and the independent variables within the framework of the ARDL model.

This study contains a dependent variable representing (exports), and three independent variables (the exchange rate defined as (one dollar = pounds), gross domestic product (GDP), and inflation). It is worth noting that all these variables are factual, as they have been divided into the general level of prices to avoid the effects of inflation. The logarithmic form of the function has also been used.

The ARDL method includes several steps. First is the Bounds Test; this includes estimating the Unconstrained Error Correction Model (UECM) to test the existence of a stable long-term equilibrium relationship between the dependent variable and the explanatory variables of the model, as shown by the following equation:

$$\begin{aligned} dlog(X_t) = &\sum_{i=1}^{k-1} \sigma_{1i} dlog(X_{t-1}) + \sum_{i=0}^{k-1} \sigma_{2i} dlog(EX_{t-i}) + \sum_{i=0}^{k-1} \sigma_{3i} dlog(GDP_{t-i}) \\ &+ \sum_{i=0}^{k-1} \sigma_{4i} dlog(INF_{t-i}) + \varepsilon_t \end{aligned} \quad (1)$$

Whereby:

$dlog(X_t)$ – the first difference for the dependent variable; exchange rate
$dlog(X_{t-i})$ – a vector from the first difference of the dependent variable of the model
$dlog(EX_{t-i})$, $dlog(GDP_{t-i})$, $dlog(INF_{t-i})$ – the first difference vector for the explanatory variables of the exchange rate, GDP, and inflation, respectively, as well as the deceleration periods for the first difference for these explanatory variables ranging from zero to (k-1).

After estimating the previous equation, and according to the limits test method presented by Pesaran *et al.* (2001) and to test the existence of a long-term relationship, the F-statistic is used for the joint significance hypothesis for the coefficients of the lagged levels in the above equation, although the null hypothesis indicates no co-integration between the model variables as follows:

$$H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$$

Against the alternative hypothesis that there is a co-integration between the level of the model variables:

$$H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$$

Since the F-test has a non-standard distribution, there are two critical values for this test statistic: the lower bound value (0), and the upper bound value (1); the estimated F-statistic is compared with the critical (tabular) values of Pesaran *et al*. (2001). If the calculated F-statistic value is greater than the upper bound, then the null hypothesis will be rejected; this signifies there is a long-term equilibrium relationship between the variables. If the calculated F-statistic value is less than the lower bound, then the null hypothesis will be accepted. Finally, if the value of the F-statistic lies between the highest and lowest levels of the tabular values, the result is inconclusive

and we cannot be sure whether the variables are integrated or not. It is worth noting that these critical values depend on the number of explanatory variables in the model, as well as whether the model contains only a function constant or a time constant and trend.

If a co-integration relationship is confirmed between the model variables, the second step is to estimate the unconstrained error correction model. The optimal size of the lags for each model variable was determined using the appropriate information criteria (AIC) to determine the lags of the ARDL model (p, q, m, n, s) as in the following equation:

$$\begin{aligned} \mathrm{dlog}(X_t) = & \sum_{i=1}^{p} \gamma_{1i} \mathrm{dlog}(X_{t-i}) + \sum_{i=0}^{q} \gamma_{2i} \mathrm{dlog}(EX_{t-i}) + \sum_{i=0}^{m} \gamma_{3i} \mathrm{dlog}(GDP_{t-i}) \\ & + \sum_{i=0}^{n} \gamma_{4i} \log(\mathrm{dINF}_{t-i}) + \varepsilon_t \end{aligned} \tag{2}$$

Where (p, q, m, n) denote the optimal number of lags for the model variables. To achieve a long-term effect, the model's coefficients are estimated.

The final step in the ARDL approach to co-integration is to estimate the Error Correction Model (ECM) that includes the error correction term obtained as residuals of the long-run regression equation with one lag, as well as the first difference of all variables and lags for each variable, and the function constant as in the following equation:

$$\begin{aligned} \mathrm{dlog}(X_t) = & \sum_{i=1}^{p-1} \sigma_{1i} \mathrm{dlog}(X_{t-i}) + \sum_{i=0}^{q-1} \sigma_{2i} \mathrm{dlog}(EX_{t-i}) + \sum_{i=0}^{m-1} \sigma_{3i} \mathrm{dlog}(GDP_{t-i}) \\ & + \sum_{i=0}^{n-1} \sigma_{4i} \mathrm{dlog}(INF_{t-i}) + \theta EC_{t-i} + \varepsilon_i \end{aligned} \tag{3}$$

Where:

$i\sigma$: represents the short-term parameters.

EC_{t-i}: error correction factor (speed of adjustment towards long-run equilibrium).

The error correction coefficient (EC_{t-i}) marks the speed of adaptation from the short to the long term, indicating the amount of change in the dependent variable as a result of the deviation of the value of the independent variable in the short term from its equilibrium value.

The unit root test aims to examine the time-series characteristics of exports (X), exchange rate (EX), gross domestic product (GDP), and inflation (INF), ascertaining their indifference, and determining the degree of integration of each variable. Although there are many unit root tests, the Augmented Dickey-Fuller test is the choice employed in the presented treatise.

RESULTS AND DISCUSSION

Empirical Results: Variables Characteristics

An Augmented Dickey-Fuller test was used to examine the time-series properties of exports (X), exchange rate (EX), gross domestic product (GDP), and inflation (INF) (see Appendix 1), ascertaining their indifference, and determining the degree of integration of each variable (see Table 2).

Table 2: Augmented Dickey-Fuller (ADF) Unit Roots Test

Variables	ADF Statistic						State of Integration 1(d)
	Level			First Difference			
	With Constant	With Constant and Time	Without Constant and Time	With Constant	With Constant and Time	Without Constant and Time	
X	0.4868	0.6684	0.5277	0.0000***	0.0001**	0.0000***	**1(1)**
EX	0.9996	0.8940	0.9364	0.9790	0.9994	0.0118**	**1(1)**
GDP	0.9996	0.2516	1.0000	0.0068***	0.0045***	0.6224	**1(1)**
INF	0.5788	0.9288	0.3649	0.0003***	0.0009***	0.0001***	**1(1)**

Notes: **, ***, mean statistical significance at 5%, 10%, respectively
Source: Constructed by authors

Regarding the results of Augmented Dickey-Fuller presented in Table 2, it is noted that all-time series were not static at their level. Subsequently, the null hypothesis was accepted that necessitated taking the first difference for these variables to settle.

After inspecting the initial case, which is the inactivity of the time series, and determining the degree of integration of each time series separately, according to Pesaran, the first step is the Bounds Test. This comprises the assessment of the Unconstrained Error Correction Model (UECM) to test the existence of a stable long-term equilibrium relationship between the dependent variable and the independent variables, and then compare the estimated F-statistic with the critical (tabular) values.

Table 3: Co-Integration Test Results Using Bounds Test

Edition	F-Statistic	K
Model	5.02	3
Critical values	Minimum (0)1	Maximum (1)1
On level 1%	3.42	4.84
On level 5%	2.45	3.63
On level 10%	2.01	3.10

Note: (1) and (0)1, the values of the critical boundary table of Pesaran *et al*., K represents the number of independent variables, which is 3
Result: There is a co-integration relationship
Source: Constructed by authors

The results shown in Table 3 indicate that the calculated F-statistic is equal to 5.02, which is greater than the upper limit of the critical values in the model proposed by Pesaran at the 1%, 5%, and 10% levels. This therefore supports the rejection of the null hypothesis at these levels of significance, confirming the existence of long-run equilibrium relevance between exports and the independent variables.

Using AIC, it can be seen that the slowdown intervals obtained using the Eviews 9.5 program are Selected Model: ARDL (1, 0, 0, 0) for one period for exports; it did not lag the variables. Eventually, by conducting the estimation process, the results came in its last form as shown by Equation 3 (see Appendix 2).

Table 4: Unconstrained Error Correction Model UECM Test Results

Variables	Parameters	Standard Error	T Test	Probability
LOG(X(-1))	0.540398	0.180563	2.992854	0.0060
LOG(EX)	0.013967	0.074209	0.188209	0.8522
LOG(GDP)	0.797740	0.345432	2.309400	0.0291
LOG(INF)	-0.154761	0.101236	-2.528716	0.0384
Statistical				
R-squared	0.830915	Durbin-Watson stat		1.693380
Adjusted R-squared	0.811406	S.D. dependent var		1.006055

Source: Constructed by authors

Table 4 infers that the estimated coefficient of the first delay in exports is significant at the 1% level. We detect that both GDP and inflation are significant at the 5% level, while the exchange rate was not significant.

The 83% change in exports can be explained by the alteration in the slowed exports for one period and GDP. The rate of inflation, which is very high, indicates the existence of model alignment and indicates the explanatory power of the proposed determinants in interpreting the changes in Sudan's exports during the period 1990-2020 (for details see Appendix 3).

Table 5: Long-Run Model Estimation Results

Variables	Parameters	Standard Error	T Test	Probability
LOG(EX)	0.030389	0.167523	0.181400	0.8575
LOG(GDP)	1.735719	0.201059	8.632881	0.0000
LOG(INF)	-0.336730	0.153305	-2.196470	0.0372

Source: Constructed by authors

Table 5 shows that the coefficients of the long-run exchange rate function can be formulated as follows:

$$\text{Cointeq} = \text{LOG(X)} - (0.0304*\text{LOG(EX)} + 1.7357*\text{LOG(GDP)} - 3367*\text{LOG(INF)})$$

From the long-term equation, we can conclude that:

- the explanatory variables (the exchange rate and GDP) are directly related to exports, while inflation is inversely related to exports; this is consistent with the research hypotheses;
- GDP is significant at the 1% level and has a direct effect as its coefficient is (1.74), interpreting that an increase in GDP by 1% leads to an increase in exports by 1.07% in the long term;
- inflation is significant at the 5% level and has an opposite effect, as its coefficient is (-0.33), meaning that an increase in inflation by 1% leads to a decrease in exports by 0.33% in the long term;
- the exchange rate was not statistically significant; this can be explained by the fact that the policy of decreasing the exchange rate did not work because most of Sudan's exports are raw and primary materials; therefore, the devaluation policy did not cause exports to increase;
- the final step in the ARDL analysis is to estimate the constrained error correction model that represents the relationship between exports and their main determinants in the short term, using the ARDL model as shown in Table 6 below.

Table 6: The Results of the Test of the Constrained Error Correction Model of the Short-Term Relationship (ECM)

Variables	Parameters	Standard Error	T Test	Probability
DLOG(EX)	0.013967	0.074209	0.188209	0.8522
DLOG(GDP)	0.797740	0.345432	2.309400	0.0291
D(INF)	-0.154761	0.101236	-2.528716	0.0384
CointEq(-1)	-0.459602	0.180563	-2.545383	0.0172

Source: Constructed by authors

Table 6 illustrates that the speed of modifying the model towards equilibrium or the error-correction limit, in which the two conditions have been achieved and are significant at the 1% level and takes a negative sign as expected, where its coefficient is -0.459. This indicates that the model can correct the error and return to a normal state within a period estimated (about two years and a month), implying that when exports during the short-term deviate from their equilibrium value in the long-run, an equivalent of 0.459% of this imbalance can be corrected until it reaches equilibrium in the long-run.

All the proposed determinants of exports have a significant effect in the short term and are consistent with economic theory, except for the exchange rate that has not shown its impact on exports in the short and long term.

DISCUSSION

In this section, we will discuss the size and performance of research variables, namely, Exports (X), Exchange Rate (EX), Gross Domestic Product (GDP), and Inflation Rate (INF). The analysis divides the period into three episodes: 1990-1999 launching economic liberalisation policy, 2000-2010 oil export, and 2012-2020 Post-Secession.

Table 7: First Episode 1990-1999

Year	X	X Growth Rate	EX	EX Growth Rate	GDP	GDP Growth Rate	INF	INF Growth Rate
1990	19.79	-	0.01	-	7.90	-	-	-
1991	4.94	-75.04	0.02	100.00	8.50	7.51	82.38	82.38
1992	11.96	142.19	0.13	550.00	9.06	6.57	31.56	31.56
1993	11.36	-4.99	0.22	69.23	9.47	4.57	15.82	15.82
1994	11.29	-0.70	0.40	81.82	9.57	1.01	-36.90	-36.90
1995	19.31	71.13	0.84	110.00	10.14	6.00	-43.63	-43.63
1996	20.92	8.35	1.46	73.81	11.31	11.56	70.17	70.17
1997	19.86	-5.09	1.71	17.12	12.00	6.06	-55.95	-55.95
1998	21.18	6.64	2.37	38.60	12.99	8.24	-61.29	-61.29
1999	35.00	65.27	2.58	8.86	13.54	4.23	0.84	0.84
Statistic Metrics								
0.33	89.75	6.20	10.45	116.60	0.97	23.08	17.56	Mean
53.75	55.56	2.92	1.92	166.22	0.99	61.78	8.23	Standard Deviation
16084.47	61.91	47.15	18.37	142.55	101.37	267.65	46.89	Variation coefficient

Source: Constructed by authors

As can be seem from Table 7:

The mean of exports during this period was 17.56 million pounds, with a standard deviation of 8.23%. This indicates a convergence between the volume of exports from year to year. The annual growth rate of exports reached 23.8%.

The mean of the exchange rate during this period was 0.98, with a standard deviation of 0.99; showing a strong convergence between the exchange rate from one year to another. The average annual growth rate of the exchange rate reached 116.60%.

The mean of the GDP amounted to 10.45 million pounds, with a standard deviation of 1.92, underlining the convergence of the output from one year to another. GDP average annual growth rate was 6.20%.

The mean inflation rate during this period was 89.75, with a standard deviation of 55.56%, while the average inflation rate during this period was 0.33%. It can be seen that inflation rates gradually decreased after the application of the economic liberalisation policy in 1992.

Table 8: Second Episode 2000-2011

Year	X	X Growth Rate	EX	EX Growth Rate	GDP	GDP Growth Rate	INF	INF Growth Rate
2000	78.71	-	2.57	-	14.67	-	7.76	-
2001	67.93	-13.70	2.61	1.56	16.26	10.80	4.40	-43.28
2002	77.25	13.73	2.62	0.38	17.23	6.00	6.90	56.66
2003	90.76	17.49	2.60	-0.76	18.32	6.29	6.25	-9.39
2004	122.01	34.43	2.51	-3.46	19.26	5.14	9.52	52.42
2005	136.94	12.24	2.31	-7.97	20.34	5.64	8.59	-9.78
2006	135.08	-1.36	2.01	-12.99	21.67	6.53	7.20	-16.25
2007	186.65	38.18	2.05	1.99	22.92	5.73	6.21	-13.76
2008	222.41	19.16	2.18	6.34	23.42	2.18	14.30	130.49
2009	150.37	-32.39	2.24	2.75	24.87	6.21	11.24	-21.41
2010	191.59	27.41	2.50	11.61	26.48	6.49	12.98	15.45
2011	153.81	-19.72	2.68	7.20	27.51	3.87	18.08	39.30
Statistics Metrics								
16.40	9.45	5.90	21.08	0.60	2.41	8.68	134.46	Mean
49.78	3.99	2.09	4.10	6.94	0.24	22.81	49.75	Standard Deviation
303.44	42.21	35.43	19.44	1147.82	9.85	262.90	37.00	Variation Coefficient

Source: Constructed by authors

From Table 8 we can notice that:

The mean of exports during this era amounted to 134.46 million pounds, with a standard deviation of 49.75%. The annual growth rate of exports reached 8.68%.

The mean of the exchange rate during this period was 2.41, with a standard deviation of 0.24; this indicates a convergence between the exchange rate from one year to another. The average annual growth rate of the exchange rate was 0.60%.

The mean of the GDP amounted to 21.08 million pounds, with a standard deviation of 4.10. The average annual GDP growth rate was 5.90%.

The mean of the inflation rate during this period was 9.45, with a standard deviation of 3.99%. This indicates a convergence; the average inflation rate during this period was 16.40%.

Table 9: Third Episode 2012-2020

Year	X	X Growth Rate	EX	EX Growth Rate	GDP	GDP Growth Rate	INF	INF Growth Rate
2012	67.31	-	3.75	-	27.70	-	35.60	-
2013	95.09	41.27	4.75	33.05	29.60	6.36	36.50	2.53
2014	78.02	-17.95	5.73	20.63	31.60	6.76	36.90	1.10
2015	65.45	-16.11	6.04	5.41	32.80	3.80	16.90	-54.20
2016	54.08	-17.37	6.18	2.32	34.10	3.96	17.75	5.03
2017	67.66	25.11	6.68	8.09	35.90	5.28	32.35	82.26
2018	44.56	-34.14	29.37	339.67	37.90	5.57	72.00	122.55
2019	134.23	201.24	45.77	55.83	36.29	-4.25	57.00	-20.83
2020	137.98	2.79	54.00	17.98	37.36	2.95	114.00	100.00
Statistics Metrics								
29.80	46.56	3.87	33.69	60.37	18.01	23.11	82.71	Mean
63.34	30.68	3.56	3.55	114.19	19.82	76.18	33.39	Standard Deviation
212.52	65.90	92.19	10.53	189.14	110.03	329.70	40.37	Variation Coefficient

Source: Constructed by authors

Table 9 describes that:

The mean of exports during this period amounted to 82.71 million pounds, with a standard deviation of 33.39%; this indicates a convergence between the volumes of exports from year to year. The annual growth rate of exports reached 23.11%.

The mean of the exchange rate during this period was 18.01, with a standard deviation of 19.82; this indicates a strong convergence between the exchange rate from one year to another. The average annual growth rate of the exchange rate was 60.37%.

The mean of GDP amounted to 33.69 million pounds, with a standard deviation of 3.55%. The average annual growth rate of GDP was 3.87%.

The mean of the inflation rate during this period was 46.56, with a standard deviation of 30.68%; this indicates a convergence. The average inflation rate during this period was 29.80%.

Table 10: Episodes' Comparison

Variables	First Episode (Mean)	Second Episode (Mean)	Third Episode (Mean)
Exports	17.56	134.46	82.71
Exchange Rate	0.97	2.41	18.01
Domestic Product	10.45	21.08	33.69
Inflation	89.75	9.45	46.56

Source: Constructed by authors

From Table 10 we find that the mean of exports during the first episode was 17.56 compared to 134.46 in the second episode of the study, estimated at an average of 116.9; this is attributed to oil exports that led to an increase in the volume of exports. Exports sharply decreased in the third period to 82.71; this is the effect of oil loss following the secession of South Sudan.

We also note that the average exchange rate of the national currency against the dollar during the three episodes showed an increase of 0.97, 2.41, and 18.01 respectively. This is a continuous increase. Augmentation was significant during the third period, rising to 18.01; this is ascribed to the loss of oil revenues that affected the balance of payments.

We observe that the average GDP during the three episodes recorded an increase, reaching 10.45 in the first episode compared to 21.08; this is attributed to the flow of foreign investment. It continued to rise during the third episode to reach 33.69, due to the expansion of the economy.

Average inflation was 89.75 during the first episode but showed a significant decrease during the second episode to 9.45. This was due to the comprehensive structural adjustment programme initiated by Abdul Wahab Osman, Former Finance Minister. As a result of the secession of South Sudan, inflation rose again during the third episode, reaching 46.56.

Table 11: Inflation and Exports During the Period 1990-2020

Year	Inflation	Exports
1990	65.30	19.79
1991	119.10	4.94
1992	156.69	11.96
1993	181.47	11.36
1994	114.50	11.29
1995	64.55	19.31
1996	109.84	20.92
1997	48.39	19.86
1998	18.73	21.18
1999	18.89	35.00
2000	7.76	78.71
2001	4.40	67.93
2002	6.90	77.25
2003	6.25	90.76
2004	9.52	122.01
2005	8.59	136.94
2006	7.20	135.08
2007	6.21	186.65
2008	14.30	222.41

(continued)

Table 11: Inflation and Exports During the Period 1990-2020 *(continued)*

Year	Inflation	Exports
2009	11.24	150.37
2010	12.98	191.59
2011	18.08	153.81
2012	35.60	67.31
2013	36.50	95.09
2014	36.90	78.02
2015	16.90	65.45
2016	17.75	54.08
2017	32.35	67.66
2018	72.00	44.56
2019	57.00	134.23
2020	114.00	137.98

Source: Constructed by authors

As shown in Table 11, during the first episode there was an annual increase in inflation, then a decrease recorded in 1998 (18.37) and 1999 (18.89). This pattern compared to an increase in the level of exports from one year to another to reach the highest level of exports in 1999 (35.00) coupled with decreased inflation of its oil's export effect.

Inflation decreased further in 2001, reaching (4.40), while 2011 recorded the highest inflation rate (18.08). During the same episode, exports began to increase until they reached their highest level in 2008 (222.41), followed by an increase of (191.59) in 2010. The highest level of inflation was in 2011 where it reached (18.08).

During the third episode of the study, inflation recorded a continuous increase until it reached its highest level in 2020, where it reached 114.00. This was due to a deterioration of productive sectors and chronic revenue deficit. We noticed a fluctuation pattern of exports during this episode.

CONCLUSIONS AND POLICY IMPLICATIONS

Based on the results, it can be concluded that research on the inflation-export nexus in Sudan has clearly shown inflation's negative impact on exports over the period 1990-2020. Broadly speaking, long-term results indicate that the most important variable affecting exports is GDP, followed by inflation.

Interestingly, the outcome affirms that the exchange rate was not significant in either the short or long term. This was explained by the fact that the exchange rate policy did not succeed because most of Sudan's exports are raw materials, so the devaluation policy did not lead to an increase in these exports.

Unquestionably, production is the base of the national economy, and this is why GDP is one of the most influential variables that affect exports.

Inflation is significant at the 5% level and has an opposite effect; its coefficient is -0.33, meaning that an increase in inflation by 1% leads to a decrease in exports by 0.33% in the long term. There is a negative impact of inflation on exports in the short and long term, so that an increase in inflation leads to an increase in production costs; this reduces production and therefore exports decline. This result is consistent with the characteristics of the Sudanese economy; it suffers from narrow base of production sectors, lack of carrying capacity, and inadequate investment climate. Undoubtedly, these factors are heavily affected by inflation.

The speed of modifying the proposed model towards equilibrium or the error-correction limit, in which the two conditions have been achieved that it is significant at the 1% level and takes the negative sign as expected. Its coefficient is -0.459; this indicates that the model can correct the error and return to the normal situation within a period estimated (about two years and a month), meaning that when exports during the short-term deviate from their equilibrium value, an equivalent of 0.459% of this imbalance can be corrected until it reaches equilibrium in the long-run.

The results are consistent with a plethora of studies globally that found that uncontrolled inflation leads to distortions in economic structure; consequently, investments were diverted to services and smuggling instead of real sectors. Therefore, it is mandatory to target inflation as a prerequisite in implementing export development strategy. It is recommended that there are more studies investigating the inflation-export nexus applying on certain commodities.

Reconsidering inflation in export development strategy will upgrade real sectors' productivity, strengthen the value chain, and diversify exports whether in components or markets.

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APPENDIXES

Appendix 1: Export, Exchange Rate, Gross Domestic Production and Inflation (1990-2020)

	Export (Millions SD)	Exchange Rate (1 USD = ..SD)	Gross Domestic Product (Millions SD)	Inflation
Year	X	EX	GDP	INF
1990	19.79	0.01	7.90	65.30
1991	4.94	0.02	8.50	119.10
1992	11.96	0.13	9.06	156.69
1993	11.36	0.22	9.47	181.47
1994	11.29	0.40	9.57	114.50
1995	19.31	0.84	10.14	64.55
1996	20.92	1.46	11.31	109.84
1997	19.86	1.71	12.00	48.39
1998	21.18	2.37	12.99	18.73
1999	35.00	2.58	13.54	18.89
2000	78.71	2.57	14.67	7.76
2001	67.93	2.61	16.26	4.40
2002	77.25	2.62	17.23	6.90
2003	90.76	2.60	18.32	6.25
2004	122.01	2.51	19.26	9,52
2005	136.94	2.31	20.34	8.59
2006	135.08	2.01	21.67	7.20
2007	186.65	2.05	22.92	6.21
2008	222.41	2.18	23.42	14.30
2009	150.37	2.24	24.87	11.24
2010	191.59	2.50	26.48	12.98
2011	135.81	2.68	27.51	18.08
2012	67.31	3.57	27.70	35.60
2013	95.09	4.75	29.60	36.50
2014	78.02	5.73	31.60	36.90
2015	65.45	6.04	32.80	16.90
2016	54.08	6.18	34.10	17.75
2017	67.66	6.68	35.90	32.35
2018	44.56	29.37	37.90	72.00
2019	134.23	45.77	36.29	57.00
2020	137.98	54.00	37.36	114.00

Source: Central Bureau of Statistics, Ministry of Finance, Central Bank of Sudan

Appendix 2: Auto Regressive Distributed Lag Model ARDL

Dependent Variable: LOG(X)
Method: ARDL
Date: 07/09/21 Time: 11:25
Sample (adjusted): 1991 2020
Included observations: 30 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (0 lag, automatic): LOG(EX) LOG(GDP) LOG(INF)

Fixed regressors:
Number of models evaluated: 4
Selected Model: ARDL(1, 0, 0, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(X(-1))	0.540398	0.180563	2.992854	0.0060
LOG(EX)	0.013967	0.074209	0.188209	0.8522
LOG(GDP)	0.797740	0.345432	2.309400	0.0291
LOG(INF)	-0.154761	0.101236	-2.528716	0.0384
R-squared	0.830915	Mean dependent var		4.055638
Adjusted R-squared	0.811406	S.D. dependent var		1.006055
S.E. of regression	0.436904	Akaike info criterion		1.305360
Sum squared resid	4.963019	Schwarz criterion		1.492187
Log likelihood	-15.58041	Hannan-Quinn criter.		1.365128
Durbin-Watson stat	1.693380			

Note: *p-values and any subsequent tests do not account for model selection

Appendix 3: ARDL Cointegrating and Long Run Form

ARDL Cointegrating And Long Run Form
Dependent Variable: LOG(X)
Selected Model: ARDL(1, 0, 0, 0)
Date: 07/09/21 Time: 11:26
Sample: 1990 2020
Included observations: 30

Cointegrating Form				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
DLOG(EX)	0.013967	0.074209	0.188209	0.8522
DLOG(GDP)	0.797740	0.345432	2.309400	0.0291
D(INF)	-0.154761	0.101236	-2.528716	0.0384
CointEq(-1)	-0.459602	0.180563	-2.545383	0.0172
Cointeq = LOG(X) - (0.0304*LOG(EX) + 1.7357*LOG(GDP) - 0.3367*LOG(INF))				
Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(EX)	0.030389	0.167523	0.181400	0.8575
LOG(GDP)	1.735719	0.201059	8.632881	0.0000
LOG(INF)	-0.336730	0.153305	-2.196470	0.0372