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RESEARCH

The impact of the exchange rate systems on macroeconomic indicators: an evaluation study on Sudan experience 1970–2019)

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This study followed both descriptive and correlation approaches to evaluate the impact of the application of the exchange rate systems on Sudan's macroeconomic indicators from 1970 to 2019. During the 1970s, Sudan adopted the system of fixing exchange rates, and the "managed exchange rate" with the successive devaluation of the local currency during 1980s. During 1990s, the floating and liberalization policy of the exchange rate had been adopted beside the system of the crawling peg between 1997 and 1999. During the first decade of the millennium (i.e., the period of the flow of the oil revenues), Sudan followed a managed exchange rate system and during the second decade (the period of the extreme scarcity of foreign exchange resources after the secession of the southern Sudan). This study concluded that the systems of the fixing exchange rate, the crawling peg and the systems managing exchange rate that are closer to fixing positively supported the macroeconomic indicators, while the systems of exchange rate that are closer to liberalization, floating and flexibility negatively affected the exports, imports gross domestic product (GDP), personal income, and increasing the inflation rate. One of the most important recommendations of this study is the need to adopt a system of the exchange rate that is closer to fixing to ensure the improvement of the macroeconomic indicators.

Keywords: exchange rate system, fixing exchange rate, floating and managed exchange rate systems, economic indicators

Introduction

Choosing the appropriate exchange system is one of the challenges faced by the economies of developing countries, in particular, as the exchange systems must, when applied, take into account the characteristics of these emerging economies, the degree of their financial openness internationally, the solidity of their internal economic system, etc. The continuity of the transformation in the application of exchange systems that follow the fixation of the exchange rate and those that follow the floating of the exchange rate or those intermediate systems puts us before the problem of choosing the appropriate exchange system. However, there is, of course, no absolute ideal exchange system, specific to each country, and this necessitates the necessity of studying the various effects of choosing the exchange system on the performance of overall economic indicators. Emerging economies, as in Third World countries, in particular, and according to many studies, have no choice but to adopt radical solutions. It consists of unlimited fixation of the exchange rate or leaving it to managed floating.

Reforming exchange systems requires the necessity of researching the existing relationship between exchange systems and their performance at the macroeconomic level by identifying the effects on the movement of exports and imports, domestic product, personal income, inflation rate, etc. Therefore, this study came to find out Sudan's experience in implementing exchange systems. The various exchange

rates and the effects of these systems on the performance of macroeconomic indicators for the period from 1970 to 2019, and then evaluate this experience and come up with appropriate results and recommendations.

Study problem

The problem of the study is to identify the economic effects resulting from adopting various exchange rate systems. Accordingly, the problem of the study can be formulated in the following question: To what extent has the application of exchange rate systems affected the overall economic indicators in Sudan for the period from 1970 to 2019?

Have the exchange systems that are closer to stabilization affected negatively or positively on exports, imports, domestic product, personal income, and the inflation rate? Have the exchange systems closer to floating affected negatively or positively on exports, imports, domestic product, personal income, and the inflation rate?

Study hypothesis

Null hypothesis H0: There is no effect of the exchange systems followed in Sudan on the volume and movement of exports.

Alternative hypothesis H1: There is an impact of the exchange systems followed in Sudan on the volume and movement of exports.

Null hypothesis H0: There is no effect of the exchange systems followed in Sudan on the volume and movement of imports.

Alternative hypothesis H1: There is an impact of the exchange systems followed in Sudan on the volume and movement of imports.

Null hypothesis H0: There is no effect of the exchange rate systems followed in Sudan on the size and movement of the gross domestic product (GDP).

Alternative hypothesis H1: There is an impact of the exchange systems followed in Sudan on the size and movement of the GDP.

Null hypothesis H0: There is no effect of the exchange systems followed in Sudan on personal income.

Alternative hypothesis H1: There is an impact of the exchange systems followed in Sudan on personal income.

Null hypothesis H0: There is no effect of the exchange rate systems followed in Sudan on the inflation rate.

Alternative hypothesis H1: There is an impact of the exchange rates followed in Sudan on the inflation rate.

Study objectives

This study aims to

1. identify the positives and negatives of different exchange systems on macroeconomic indicators,
2. determine the nature of the relationship between exchange systems and the movement of exports and imports in Sudan experience 1970–2019,
3. determine the nature of the relationship between exchange systems, GDP, and personal income in the Sudan experience 1970–2019,
4. determine the nature of the relationship between exchange systems and inflation rates in the Sudan experience 1970–2019, and
5. reaching results and recommendations that indicate adopting policies to implement ideal exchange rate systems that support economic performance in Sudan.

Study methodology

The study will follow the descriptive correlational approach through an econometrical study using multiple linear regression to evaluate Sudan's experience for the period from 1970 to 2019 to determine the impact of the exchange rate systems applied (as explanatory variables) by period, on the performance of some macroeconomic indicators such as exports, imports, GDP, and the level of personal income, as well as inflation rate (all as dependent variables).

Study period

It covers the time periods extending from 1970 up to 2019.

Exchange system

Refers to the arrangements followed by countries, either by leaving the determination of the foreign currency exchange rate to market forces on both the supply and demand

TABLE 1 | Distribution of countries according to the exchange rate systems during the period 2013–2021.

Exchange systems	2013	2021
Solid fixing system	13.2%	13%
Easy fixing system	42.9%	47.7%
Floating	34%	33.1%
Others managed system	9.9%	6.2%
Total	100%	100%

sides, or by the monetary authorities when they control the supply of the foreign currency or the demand for it, or both. The control assumes that the monetary authority chooses a specific exchange rate, and knows the reason for the deviation of the market price from the officially specified price, whether it comes from either excess supply or excess demand. Therefore, no authority can control the price without noticing what is pushing the price to higher or lower than the fixed or desired price, whether it comes from the demand side or the supply side.

In the period before World War I, the countries of the world followed a fixed exchange rate system based on the gold standard, which determined the value of the currency in gold while maintaining the convertibility of the currency into gold. Departure from the gold system was permitted temporarily in cases of emergency and war, provided that it was returned as long as the state of emergency ended, as happened after World War I, then the return in 1925 AD, abandonment in 1931 AD, and then it evolved to the adjustable peg in 1945 AD (Bretton Woods Agreement). At the beginning of the 1970s, the floating system was dissolved to influence the inconsistent financial policies followed by industrialized countries, especially the United States of America, which followed an expansionary financial and monetary policy to finance the Vietnam War.

Floating exchange rates are divided into free-floating exchange rates that do not interfere with the monetary authorities and allow the exchange rate to be determined on the basis of market forces, and directed floating exchange rates that are intervened by the monetary authorities (10).

International Monetary Fund reports

From **Table 1**, the solid fixation indicates either the country's reliance on alternative currencies (such as euro, dollar, etc.) instead of the local currency in internal transactions and external payments. It also indicates the use of the National Currency Committee system, where the issuance of the local currency is restricted except under the condition covering the national currency with the foreign currency associated with it. Here, the central bank cannot exercise the function of lender of last resort.

As for easy stabilization, the monetary authority uses the appropriate available means to keep the exchange rate within certain limits and range of movement above or below the specified price. In this context, some countries also decide to adjust the exchange rate according to inflation differences in what is known as the crawling peg stabilization system. Stabilization systems, of course, restrict monetary policy and the freedom of monetary authorities to manage liquidity or interest rates, even with increased financial openness.

As for the floating system, determining the exchange rate depends on the market without interference from the monetary authorities, whose intervention is limited to correcting large deviations during specific periods in the fiscal year. The other managed arrangements systems are systems closer to fixation.

It is also noted from the table that the systems that are closest to facilitation and flexibility in managing the exchange rate are followed by more than 80% of countries, while less than 20% of countries follow systems of stabilization and determination. This classification of countries according to the adoption of exchange rate systems explains the attempt of countries to avoid the negatives when following one system rather than the other. It is also noted that about 4% of countries have shifted from rigid stabilization, managed systems, and free-floating toward easy pairing stabilization for the purpose of benefiting from the advantages of floating. Financial openness is not compatible with a fixed exchange rate, as monetary expansion increases inflation rates and thus increases the cost of exports, and this has a negative impact on export revenues. At the same time, reducing government spending makes imports cheaper than local products. This explains the ineffectiveness and inefficiency of monetary policy in following the exchange rate stabilization system.

Also, following the exchange rate floating system requires liberalizing the management of liquidity and interest rates so that monetary policy becomes more efficient. However, this in return requires that the characteristics of the economy be characterized by diversification in exports and then the spontaneity of cash flows to the exchange market. It also requires the presence of an appropriate financial depth and a close relationship between cash flows with interest rates.

It is noted from **Table 2** that the percentage of the countries that relied on the dollar and euro currencies as nominal stabilizers was equivalent to 32.7%, while this percentage had been equivalent to 34.4%. In contrast, the percentage of the countries that relied on other currencies was 11% and turned to be equivalent to 8.8%. Also, the percentage of countries that relied on the monetary aggregates stabilizer was 13.6% and turned to be equivalent to 13%, while the percentage of the countries that followed the policy of targeting inflation as a nominal stabilizer was 17.8% and turned to be equivalent to 20.3%, and the percentage of those countries that followed other policies as stabilizers was 20.4% and turned to be increased to 22.3%. From this analysis, it is noted that the countries in stabilizing exchange rates took various other

TABLE 2 | Percentage of countries that relied on the dollar and euro currencies according to monetary policy and exchange price as nominal fixers.

Year	US $	Euro	Salal (baskets)	Other currency	Liquidity balances summation	Targeting inflation	Others	Total
2013	20.3	14.1	6.8	4.2	13.6	17.8	20.4	100
2021	19.2	13.5	4.1	4.7	13	20.3	22.3	100

www.economic collections/new economic theory files/the exchange rate as a driver of the currency market.

tools. Other countries also moved toward policies targeting inflation, which has become a disturbing phenomenon for all the other world counties' economies.

From **Table 2**, it is also noted that there is neither a single exchange rate system followed nor a specific nominal fixer for exchange rates. All these depend on the economic situation of each country and the policies followed in targeting economic goals.

The concept of foreign exchange rate

To understand the concept of the foreign exchange rate, it is necessary to define the meaning of foreign exchange as, terminologically, it carries more than one meaning—sometimes it refers to the concept of foreign exchange and other times, it means the process of exchanging foreign money or it expresses both meanings at the same time (1) (the exchange rate can also express the price of one currency in another currency, or it is the ratio of exchange of two currencies, as one of the two currencies is considered a commodity and the other currency is considered its price). The exchange rate is the number of units that must be paid for a particular currency to obtain a unit of another currency (2).

The exchange rate is defined as the number of units of the local currency against one unit of foreign currency, or vice versa, the number of units of the foreign currency against one unit of the local currency. In short, it is the value of one currency in terms of another currency.

Economic theories explaining the exchange rate

Purchasing power parity theory

This theory came to search for how to determine the parity prices between the currencies of countries other than the gold standard (the parity price between two currencies occurs when the purchasing power of each country's currency in its internal market is equal to its purchasing power in the market of another country after converting it to the currency of this country according to the exchange rate that achieves this parity) Bonouh Shuaib and Khayyat Rahima (2011), Therefore, this theory in its absolute form attempts to clarify that the purchasing power of the currency inside the country determines its purchasing power abroad and therefore the external exchange rate is determined by internal prices.

$$€ = p/p^*$$

where € is the exchange rate symbol, p is the domestic price index, and p^* is the foreign price index. Therefore, the domestic price level is obtained as follows:

$$p = € \times p^*$$

This theory also tried to take into account the proportionality of changes in domestic and foreign prices. Despite criticism of this theory, the fact that many goods do not enter into foreign trade, and the increase in national income increases through imported goods and thus increases the demand for foreign currencies without affecting internal purchasing power; despite the criticism, the theory attempts to find an explanation for exchange rate movements in the event of differences in inflation levels between countries.

Interest rate parity theory

Many economic theories confirm that the exchange rate depends on other entities and are largely determined by financial variables such as local and foreign interest rates (the interest rate parity theory expresses the existing relationship that connects the money market and the exchange market. The level of the interest rate in the two countries must reflect the relationship in changes in expected exchange rates (3). The general rule of this theory is that the currency of any country A depreciates from the value of the currency of any other country B if the return interest rate in B is greater than A because investors will obtain interest rates that are higher than what prevails in the local market.

Balances theory

This theory explains the exchange rate according to the state of the trade balance (4). If the balance achieves a surplus, which means that the value of exports is greater than the

value of imports, the demand for the local currency increases, so its value increases, and vice versa; if the balance records a deficit, which means that the value of imports is greater than the value of exports, the demand for foreign currency increases, so its value increases.

Quantity theory of money

The increase in the amount of money supply and circulation in a country's economy is considered influential in determining the currency exchange rate through an increase in the prices of local goods.

The cost of exports becomes high and loses its competitiveness, and residents accept to purchase these goods from abroad; so, the demand for foreign currency increases while the local currency exchange rate deteriorates. "Changes in the monetary supply have an impact on exchange rates (5)."

The theory of excess adjustment of the exchange rate

In 1936, Dor Naboush tried to explain the imbalance in the exchange rate through the structure affecting the exchange rate. "The reaction of prices in the economy to any monetary crisis does not all correct at the same speed. Financial assets in the exchange market correct at a faster pace than commodity prices, and exchange rate changes are subject to the interest rate in the range." Short-run and long-run purchasing power parity Mondher (1999).

The theory of speculative bubbles

This theory appeared as a result of the financial crisis in 1981, when permanent differences began to appear in the exchange market and the equilibrium value in economic fundamentals such as inflation, the balance of payments, etc. This difference is called the speculative bubble.

$$S = (\mathrm{SEQ}) + B$$

where S is the exchange rate, SEQ is the equilibrium price, and B is the speculative bubble. "A change in information in the market affects, positively or negatively, the equilibrium exchange rate. Finally, the exchange rate will correct this imbalance, and thus the bubble will burst (7)."

The relation between exchange rate and economic policy

The policy related to the exchange rate is one of the most important economic policies because it affects macroeconomic variables such as the general price level, the volume of foreign trade, the trade balance, etc. It is one of the mechanisms that is used to address imbalances, especially in light of the restrictive conditions for trade exchange. Several tools are used to implement the exchange rate policy. Exchange includes the following:

1. Under the fixed exchange rate system, the reduction of the local currency against the foreign currency is used to encourage exports and support their competitiveness, and the local currency is revalued to encourage and support imports.

2. When the local currency collapses, the authorities sell part of the cash reserves in exchange for the local currency. When the local currency improves, foreign currency is purchased to maintain the balance of foreign currencies to support the local currency.

3. In the event of a collapse of the local currency, a high interest rate will be adopted to compensate for the risk of the collapse of the local currency.

4. Implementing the exchange rate control system by adopting the special license system for foreign currency sales and purchases.

5. Adopting a multiple exchange rate system that includes an exaggerated exchange rate system (valuation of the local currency) that supports imports, while local exports are supported by a regular exchange rate system.

Exchange rate policy tools aim to develop local industries by reducing the exchange rate of the local currency. Lowering the real exchange rate also helps make local products more competitive and increases the base of goods destined for export. Also, a rise in the real exchange rate increases the purchasing power of wages, and when the price improves the exchange rate, the level of imported inflation decreases as production costs decrease and the purchasing power of the national currency improves (6). Through the previous review, it is noted that the exchange rate policy has a relationship with monetary policy because monetary policy affects the exchange market through buying and selling bonds, using foreign reserves, and imposing restrictions on the movement of international capital,

Fiscal policy, through changes in government spending, also affects the demand for foreign currencies, and the emergence of a deficit or surplus in the general budget affects the amount of foreign exchange. Also, if countries follow a policy of freedom or protection of trade, this affects the demand and supply of foreign exchange, and thus the exchange rate is affected.

Implications of exchange systems on economic indicators

Many economic researchers have been interested in studying the impact of the application of exchange rates on exchange rate movements and the extent of their impact on macroeconomic indicators. The general price level and the flow of international funds through exports and imports and its reflection on the level of investment, production movement, and the economic growth rate are considered among the most important indicators that measure the level of economic stability.

Inflation and choosing the exchange rate system

The problem of inflation has constituted a widespread debate regarding the choice of an exchange rate system that ensures maintaining low rates of inflation in the general price level. Supporters of the fixed exchange system have emphasized that this system restricts monetary policy and thus reduces general price levels. Among the experimental studies that specialized in the subject, we found a study presented by Caramazza and Paris (7), which indicated that inflation, was weaker and more stable in countries that adopted a fixed exchange rate. Therefore, fixing the exchange rate raises and increases the confidence in holding the local currency and leads to increased demand for the currency at a certain level of money supply, which contributes to the preservation of the currency at low rates of inflation (the preference for the fixed system is more important in low-income countries that do not monitor the flow of international funds than in other countries that do not, as such monitoring reduces the degree of confidence. In addition, inflation changes are weaker in the fixed system than in the flexible system (8). On the contrary, as the supporters of the flexible exchange system pointed out (Quirk 1996) that in the long run, there will be an adjustment between the exchange rate fluctuations and inflation, so the differences between the inflation rate are likely to be canceled out, as the hypothesis of a low inflation rate under the system of fixed exchange rates, it is no longer accepted in light of some freedom given to monetary policy in this system (10).

It is noted that the supporters of the fixed exchange system focused their study on low-income countries specifically, and therefore this is the most important opinion that can be taken into account when studying the Sudanese case.

Investment and choosing exchange systems

Exchange rate fluctuations create high risks that may prompt capital owners not to direct their direct investments toward the country that suffers from fluctuations in its currency exchange rates. The greater the fluctuations in exchange rates, the lower investment capital flows and the higher interest rates.

Economic growth and exchange rate

Economic theory uses some indicators that each type of exchange rate system shows to influence economic growth, as the exchange rate can affect productivity growth.

Economic theory uses some indicators that each type of exchange rate system shows to influence economic growth, as the exchange rate can affect productivity growth. The relationship between the exchange rate and economic growth can be highlighted through the movement of capital and knowledge accumulation (a decrease in the real exchange rate reduces the cost, increases the competitiveness of goods, increases the value of capital invested in foreign currency, and also allows for increased training operations abroad and then the acquisition of skills (9); whenever the exchange rate has a degree of flexibility, this allows for the reallocation of resources in a way that raises the marginal product of resources, and at the same time, there must be relative stability that ensures increased economic growth.

Exchange rate and foreign trade systems

From the theoretical side, exchange rate systems affect the level of economic growth through their impact on the volume of international trade, as some theorists believe that the level of trade exchange tends to increase under a fixed exchange rate system because extreme fluctuations in the exchange rate increase the state of uncertainty and increase the cost of exchange internationally.

The development of exchange rate policy in Sudan (1970–2019)

The exchange rate reflects the purchasing power of the local currency against foreign currencies. Also, one of the issues related to exchange rates is the mechanism for reflecting movements in foreign exchange rates in a country into the prices of local goods and services, which affects the increase in the country's share of foreign trade and the supply of foreign exchange, which is considered the main source of the country's reserves to finance its imports and pay its obligations to the outside world. Exchange rate policies and systems in Sudan can be divided into several stages [Central Bank of Sudan (2009) Documentation Study] as discussed in the following subsections.

Exchange rate policy for the period 1956–1979 AD

- The period of stabilizing the exchange rate (1956–1979 AD):

Since the announcement of Sudan's independence, the Sudanese pound was launched by the Currency Committee. Sudan was famous for producing and exporting cotton and various agricultural products, which strengthened the value of the Sudanese pound and supported its stability. In July 1957, it was agreed with the International Monetary Fund (IMF) to set the exchange rate of the Sudanese pound at the equivalent of 2.87 dollars, meaning that the price of the dollar would be 0.35 pounds, and the price of the pound continued to be fixed until the end of the seventies.

The period of the exchange rate devaluation policy (1979–1992 AD)

In June 1979, coinciding with the preparation of the state's general budget, the price of the Sudanese pound was reduced to 2.5 dollars, with the dollar being equivalent to 0.4 Sudanese pounds. From that date, the policy of reducing the exchange rate began, which was followed within the framework of the economic stabilization policies recommended by the International Monetary Fund (IMF). The following period witnessed successive reductions, and in September 1979 it was announced that the price of the Sudanese pound would be reduced to become equivalent to 2 dollars. Also, it had been announced the double exchange rate, where the parallel exchange rate was set and was equivalent to 1.24 dollar per pound, and the free rate was applied to all imported goods except 19 goods at the official rate. The reduction policy continued until November 1981. The parallel exchange rate was canceled and the pound was reduced to 1.11 dollars. In November 1982, the price of the pound was reduced to 0.77 dollars, which means that 1 dollar is equivalent to 1.30 Sudanese pounds. Thus, the value of the Sudanese pound fell below the threshold of 1 dollar. A new exchange rate called the free exchange rate was introduced, which is equivalent to 1.8 pounds to the dollar, and the official exchange rate is 1.3 pounds to the dollar. In January 1984, the free exchange rate was reduced to 2.1 pounds to the dollar. In 1985, commercial banks were allowed to set the free exchange rate to be within 3.15 pounds to the dollar, while the official exchange rate was fixed at 2.5 pounds to the dollar.

The free exchange rate was adjusted to 3.15 pounds to the dollar, 3.25 pounds to the dollar, 3.30 pounds to the dollar, and 3.45 pounds to the dollar. In October 1987, a unified exchange rate was announced, with the official exchange rate being 4.5 pounds to the dollar. As a result of the economic deterioration, the official exchange rate reached 15 pounds to the dollar in October 1991, while the free exchange rate reached 30 pounds to the dollar.

Exchange rate floating period (1992–1999)

The economic liberalization policy was announced in February 1992. The official and free exchange rate system was abolished, and the exchange rate of the Sudanese pound was liberalized. It is determined by the Union of Banks according to supply and demand indicators. Floating the exchange rate in light of the lack of foreign exchange reserves led to a significant decline in the exchange rate and a widening of the gap between the official exchange rate and the parallel exchange rate. In 1995, regulations regulating money exchange businesses were approved under the Foreign Exchange Dealing Regulation Law.

Crawling peg during 1997–1999

According to the crawling peg policy, the exchange rate is determined by a committee composed of the Bank of Sudan, the Money Exchange, and the Union of Banks. This committee is guided by the volume of foreign exchange transactions, provided that a determination is made between the free and parallel rates. The committee announces the lower and upper limits of the purchase price for each of the banks and money exchangers, provided that it chooses which of the two limits represents the purchase price and then adds 2% to the selling price.

Managed flotation (1999–2008)

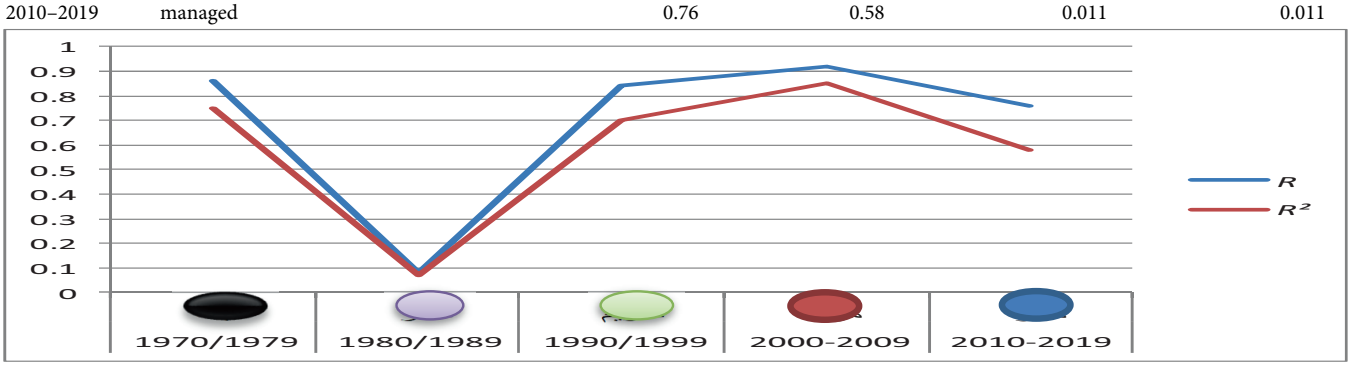
This period witnessed the stabilization of the exchange rate to increase oil revenue flows, which contributed to providing resources for the foreign exchange market. During this period, the monetary authorities implemented a managed flexible exchange rate system, where the forces of supply and demand became the basic principle, and intervention in the money market was to correct the path of liquidity in the economy.

Managed flotation and the period of scarcity of reserves (2008-2015)

Oil revenues decreased significantly due to the secession of the state of South Sudan, in addition to the decline in nonoil export revenues. This led to a decline in the value of the local currency and the emergence of the parallel market again. From 1999, exchange rates began to multiply with successive reductions in the official exchange rate (Bank of Sudan Al-Masrafi Magazine 2016).

TABLE 3 | Export variable.

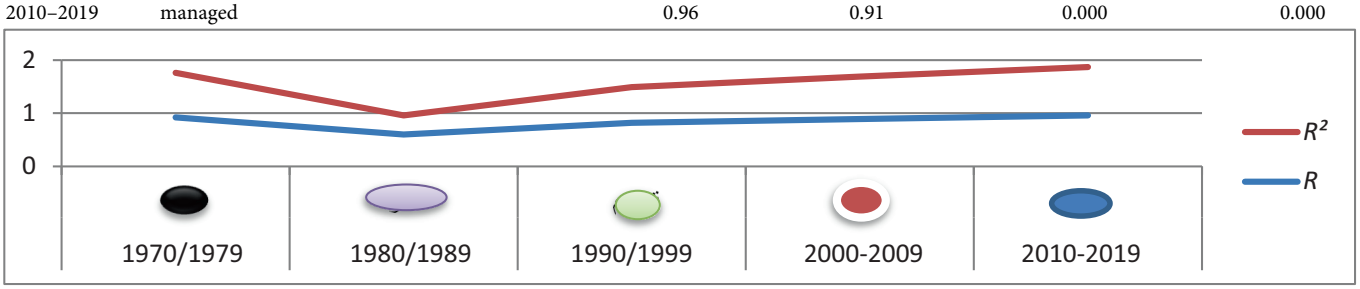
Periods	Fix	*R*	R^2	*F*-test	*t*-Test
1970–1979	Fix	0.86	0.75	0.01	0.01
1980–1989	Managed and devaluated	0.08	0.07	0.818	0.01
1990–1999	Floating and liberalization + crawling peg	0.84	0.70	0.02	0.00
2000–2009	floating	0.92	0.85	0.00	0.00
2010–2019	managed	0.76	0.58	0.011	0.011



Macroeconomic trends WB.

TABLE 4 | Import variable.

Periods	Exchange systems	*R*	R^2	*F*-test	*t*-Test
1970–1979	Fix	0.92	0.84	0.000	0.001
1980–1989	Managed and devaluated	0.60	0.36	0.06	0.000
1990–1999	Floating and liberalization + crawling peg	0.82	0.67	0.04	0.000
2000–2009	floating	0.89	0.80	0.001	0.000
2010–2019	managed	0.96	0.91	0.000	0.000



Source: Macroeconomic trends WB.

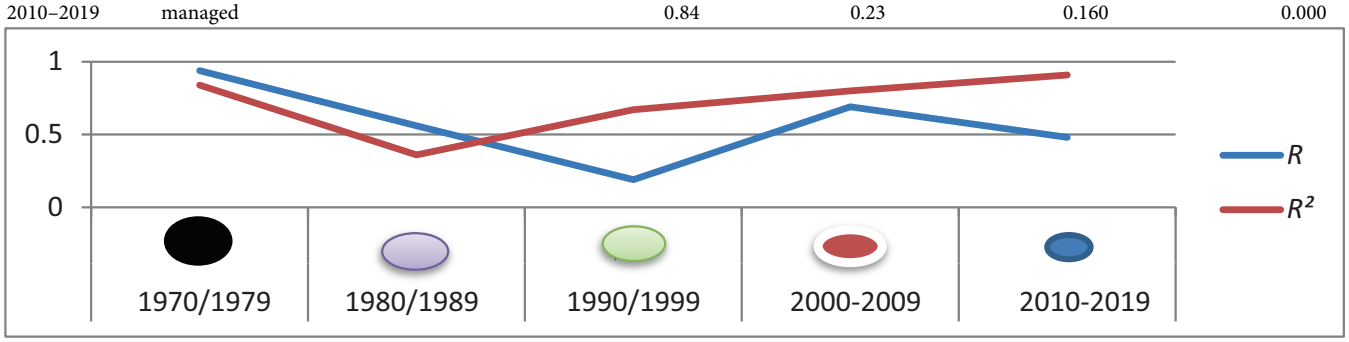
Results of analyzing the impact of exchange systems on macroeconomic indicators (Sudan experience 1970–2019 (Tables from No. 3-up to No. 8)

(A) During the 1970s (1970–1979)

(1) The fixed exchange rate system was followed, and this period witnessed stability in the exchange rate of the Sudanese pound, as it was equivalent to 2.87 dollar. The fixed exchange rate system was supportive of exports and their competitiveness, as it is noted from the analysis that the exchange rate is strongly linked to exports (correlation coefficient was 0.86). The coefficient of determination was 0.75, which is a ratio that explains the strength of the exchange rate system followed in determining the movement of exports, and this is what was indicated by the value of the adjusted correlation coefficient in the relationship of exports to the variable under study. In the same direction, the effect of the exchange rate on the movement of imports (correlation coefficient was 0.92) and the coefficient of determination was 0.84, which is an explanatory ratio that indicates the strength of the exchange system followed in determining the movement of imports, and this is indicated by the value of the adjusted

TABLE 5 | GDP variable.

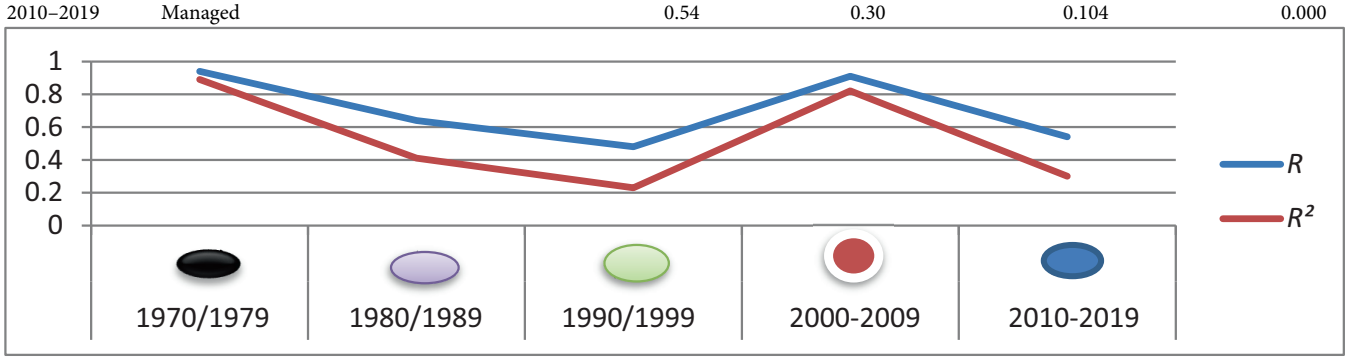
Periods	Exchange rate systems	*R*	R^2	*F*-test	*t*-Test
1970–1979	Fix	0.96	0.94	0.000	0.000
1980–1989	Managed and devaluated	0.75	0.56	0.013	0.002
1990–1999	Floating and liberalization + crawling peg	0.44	0.19	0.207	0.04
2000–2009	floating	0.83	0.69	0.03	0.01
2010–2019	managed	0.84	0.23	0.160	0.000



Source: Macroeconomic trends WB.

TABLE 6 | Personal income variable.

Periods	Exchange rate systems	*R*	R^2	*F*-test	*t*-Test
1970–1979	Fix	0.94	0.89	0.000	0.000
1980–1989	Managed and devaluated	0.64	0.41	0.045	0.001
1990–1999	Floating and liberalization + crawling peg	0.48	0.23	0.162	0.004
2000–2009	Floating	0.91	0.82	0.000	0.000
2010–2019	Managed	0.54	0.30	0.104	0.000



Source: Macroeconomic trends WB.

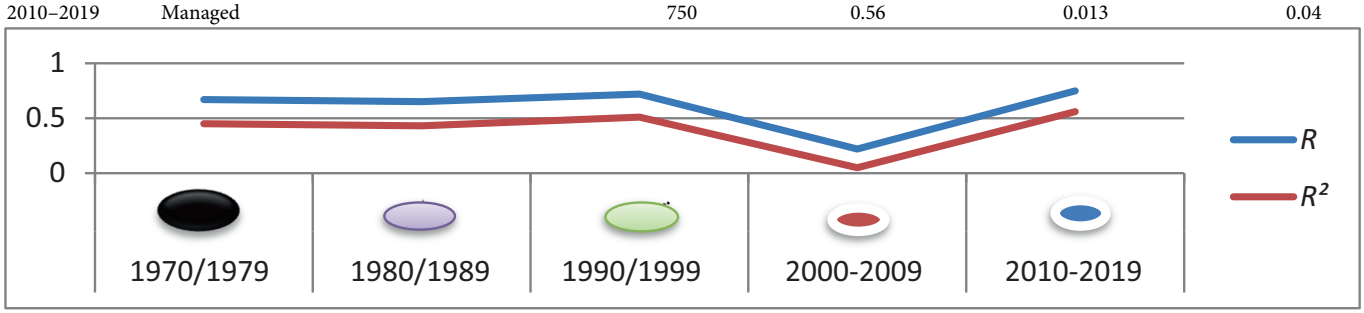
correlation coefficient in the relationship of imports to the variable under study. Also, the results of the *F*-test for means show a probability of significance less than the level of 0.05. This indicates the appropriateness of the regression line to the data and to the same extent was the result of the *t*-test, which means accepting the alternative hypothesis regarding the effect of the exchange rate system on the positive movement of exports and imports.

(2) The analysis also indicated a strong correlation between the exchange rate and the GDP (the correlation coefficient was 0.97), as was the coefficient of determination (0.94), which is a strong ratio that explains the effect of the exchange rate system on the GDP, and this is what was indicated by the value of the adjusted correlation coefficient in the GDP correlation with the variable under study. Also, the results of the *F*-test for means show a probability of significance less than the level of 0.05, which indicates that the regression line is appropriate to the data, and to the same extent was the result of the *t*-test, which means accepting the alternative hypothesis regarding the effect of the exchange rate system on the positive movement of the GDP.

(3) The analysis also indicated a very strong correlation between the exchange rate and personal income, that

TABLE 7 | Inflation variable.

Periods	Exchange rate systems	*R*	R^2	*F*-test	*t*-Test
1970–1979	Fix	0.67	0.45	0.033	0.068
1980–1989	Managed and Devaluated	0.65	0.43	0.040	0.019
1990–1999	Floating and liberalization + crawling peg	720	0.51	0.020	0.000
2000–2009	Floating	220	0.05	054	0.28
2010–2019	Managed	750	0.56	0.013	0.04



Source: Macroeconomic trends WB.

TABLE 8 | Adjusted R^2.

INF	PI	GDP	IMP	EX	Decades/indicators
0.19	0.87	0.93	0.82	0.72	70
0.36	0.34	0.50	0.29	−0.117	80
0.45	0.13	0.93	0.63	0.67	90
0.15	0.76	0.004	0.77	0.83	2000
0.51	0.21	0.13	0.90	0.29	2010

Source: Macroeconomic trends WB. INF, Inflation; PI, personal income; IMP, imports; EX, exports.

is, 0.94 and 0.89 as a determination coefficient explains that 0.89 of the reasons for the impact of personal income are due to the exchange rate system followed, and this is what was indicated by the value of the adjusted correlation coefficient in the relationship of personal income to the variable of study.

(4) In measuring the inflation index for the period, it is noted that the correlation between the exchange rate and the inflation rate was moderate (correlation coefficient was 0.67), and the results of the *F*-test indicate the suitability of the regression line to the data. To the same extent, the result of the *t*-test was for accepting the alternative hypothesis on the effect of the price system spending on inflation. However, on the contrary, the extent of accuracy and specificity in estimating the dependent variable (inflation) was very weak (the coefficient of determination was 0.45), and therefore 0.55 of the causes of inflation were due to reasons other than the exchange rate system followed, and this was indicated by the weakness of the value of the adjusted correlation coefficient, in the relationship of inflation to the variable under study.

The fixed exchange rate system followed during the seventies had a positive impact on the movement of exports, imports, GDP, and personal income, and the slight increase in the inflation rate was due to reasons other than the exchange rate system followed.

(B) During the 1980s (1980–1989)

During this period, the managed exchange rate system was followed, where successive devaluations were made of the local currency (the Sudanese pound) against the dollar. However, this measure did not move exports, so they remained oscillating. Therefore, the correlation between the exchange rate system and exports was very weak (correlation coefficient 0.084). Also, the interpretation of the effect of the exchange rate system on the volume of exports was within very weak limits (the coefficient of determination was 0.07), and this is indicated by the value of the adjusted correlation coefficient in the correlation of exports with the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous period.

(1) In general, imports moved despite the fluctuation during this period, so the correlation coefficient was average (0.60). Also, the exchange rate system was not a good explanation of the impact on imports (the coefficient of determination was 0.36). Therefore, there

are other reasons that affect it by a percentage of 0.64, and this is what the value indicates.

(2) The adjusted correlation coefficient in the correlation of imports with the variable under study, when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous period.

In light of these results, the *F*-test indicates that the regression line is not appropriate for the data, and to the same extent the result of the *t*-test was, therefore, accepting the null hypothesis regarding the lack of influence of the exchange rate system on the movement of exports and imports.

(3) It is also noted that the managed exchange rate system had a moderate impact on the size of the GDP (correlation coefficient 0.75) and that the exchange rate explains a moderate impact on the GDP (coefficient of determination 0.56) and this is indicated by the value of the adjusted correlation coefficient in the correlation domestic product with the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous period.

But in general, the results of the *F*-test were based on the fit of the regression line to the data, and to the same extent were the results of the *t*-test by accepting the alternative hypothesis on the effect of the exchange rate system on the GDP.

(4) It is also noted that the managed exchange rate system had a moderate impact on the size of personal income (correlation coefficient was 0.64), and the exchange rate had a moderate impact on personal income (coefficient of determination was 0.59). This is indicated by the value of the adjusted correlation coefficient in the personal income correlation.

With the variable under study, when adopting the gradual method to compare the correlation of the same variable with the nonindependent variable in the previous period.

However, in general, the results of the *F*-test for means were based on the fit of the regression line to the data, and to the same extent were the results of the *t*-test by accepting the alternative hypothesis on the effect of the exchange rate system on personal income.

It is noted that the managed exchange rate system during the 1980s was not significantly supportive of the movement of exports and imports, nor the GDP, nor personal income, nor a significant explanation for the inflation rate, which was more influenced by other factors.

(C) During the 1990s (1990–1999)

(1) A flexible exchange rate system was followed and the exchange rate was fully liberalized according to the directives of the Monetary Fund and the World Bank. This policy had a negative impact on the volume of exports, as they fluctuated until the mid-1990s, but following a managed exchange rate system in 1997 led to an improvement in the volume of exports, and the correlation coefficient was 0.84. The coefficient of determination (0.70) also explains the quality of the exchange rate in affecting exports, and the *F*-test indicates the suitability of the regression line to the data. To the same extent, the result of the *t*-test resulted in accepting the alternative hypothesis in the effect of the exchange rate, and this is what it indicated. It depends on the value of the adjusted correlation coefficient in the correlation of exports with the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous period.

(2) On the contrary, the volume of imports improved in general (the correlation coefficient was 0.82), and the coefficient of determination was 0.67, indicating the acceptance of the alternative hypothesis in the presence of an effect of the exchange system on imports. This is indicated by the value of the adjusted correlation coefficient in the relationship of imports to the variable under study when taking the gradual method compares the correlation of the same variable with the nonindependent variable in the previous period.

(3) The liberalization policy and high costs had a negative impact on production. The 1990s witnessed the shift of real producers from real production to consumption, which resulted in a general decline in the GDP. Therefore, the correlation coefficient was 0.44, and the exchange rate system followed did not explained the movement of output (coefficient of determination was 0.19) and this resulted in fluctuation in personal income.

The correlation coefficient was 0.48 and the interpretation and determination coefficient was 0.23 when interpreting the effect of the exchange rate on personal income. This is indicated by the value of the adjusted correlation coefficient in the relationship of personal income to the variable under study when taking the gradual method to compare the relationship of the same variable to the independent variable in the previous period.

(4) Also, the exchange rate system followed had a moderate correlation with inflation (correlation coefficient was 0.72). The result of the *F*-test for the means indicated the appropriateness of the regression line to the data. To the same extent, the result of the *t*-test indicated acceptance of the alternative hypothesis on the effect of the price system. Considering the impact of the exchange rate on the inflation rate and the coefficient of determination as 0.51, there are other factors (0.49)

that affect inflation. Therefore, we notice that inflation remained highly variable, and this is indicated by the value of the adjusted correlation coefficient when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous period.

It is noted that the system of floating and liberalizing the exchange rate during the 1990s had a negative impact on the volume and movement of exports, and in return, it contributed to an increase in imports, which resulted in an increase in the trade deficit. The flexible exchange rate system also did not support the GDP and thus personal income and it increased inflation rates.

(D) During 2000s (2000–2010)

(1) The managed exchange rate system was followed, and the period witnessed an influx of oil revenues and an improvement in economic performance. This led to a strong correlation with the impact of the exchange rate system and a positive way on exports (correlation coefficient was 0.92). Exports jumped to high levels, and the explanatory power indicated the impact of the exchange rate system. Also, the strong impact on exports is explained by the coefficient of determination (0.85). To the same extent, imports increased, indicating the strength of the correlation between the exchange rate system and imports (the correlation coefficient was 0.89). The coefficient of determination (0.80) also explains the quality of the effect of the exchange rate on the movement of imports. The result of the test of averages of the *F*-test indicates the fit of the regression line to the data. To the same extent, the result of the *t*-test indicates acceptance of the alternative hypothesis on the effect of the exchange rate system on both exports and imports.

(2) It is also noted that the positive impact of the exchange rate system on the volume of the GDP was strong (0.83) and the explanatory coefficient for the impact of the exchange rate on the GDP was 0.69; thus, the coefficient of determination was an explanation of the effect of the exchange rate on the domestic product. This is indicated by the value of the adjusted correlation coefficient in the relationship of exports to the variable under study when taking the gradual method to compare the relationship of the same variable to the independent variable in the previous period.

(3) It is also noted that the weak correlation of the exchange rate system with the inflation rate (the correlation coefficient was 0.22), and therefore the coefficient of determination was 0.05, explaining the very weak effect of the exchange rate system on inflation because there are other influential and determining factors with a percentage of 0.95 and to the same extent was the result of the *t*-test. It indicates the acceptance of the null hypothesis that there is no effect of the exchange rate on the inflation rate, and this is indicated by the value of the adjusted correlation coefficient in the relationship of inflation to the variable under study.

(4) It is also noted that the positive indicators of the gross product were reflected positively on personal income, as the correlation coefficient was very strong (0.91), and the coefficient of determination indicated that a percentage (0.82) of the impact on personal income was due to the followed exchange system. The results also indicated acceptance of the alternative hypothesis in the presence of an effect of the exchange rate system on personal income, and this is indicated by the value of the adjusted correlation coefficient in the relationship of personal income to the variable under study when taking the gradual method to compare the relationship of the same variable to the independent variable in the previous period.

It was noted during the first period of the millennium that the retreat from the system of complete liberalization of the exchange rate and the adoption of a managed exchange system, in light of stable economic conditions and oil export revenues, led to an improvement in the movement of exports and imports, and an improvement in the gross domestic product and personal income. The exchange rate system did not affect the increase in inflation rates, as There are factors other than the exchange rate that were very influential (0.78) on inflation rates.

(E) During the period of 2010s (2010–2019)

(1) A more flexible exchange rate system was followed, and this led to the emergence of a parallel price and currency trade spread, so the government resorted to reducing the exchange rate, but this step did not stimulate exports, especially after petroleum exports stopped after the secession of South Sudan; so, they decreased by 0.77. This justifies the extent of the correlation and the negative impact of the exchange rate system on exports (correlation coefficient was 0.76) and the coefficient of determination showed that 0.58 of the effect is due to the followed exchange system, but there are other factors that affect by 0.42 and this is what was indicated by the value of the adjusted correlation coefficient in the relationship of exports to the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous era.

(2) On the contrary, imports decreased by (0.74), which indicates the strength of the relationship between the exchange rate system and imports (0.96). It also indicates the strength of the interpretation of the exchange rate in influencing imports (the coefficient of determination was 0.91). The results of the *F*-test indicate the suitability of the regression line to the data, and to the same extent it was the result of the *t*-test to accept the alternative hypothesis on the effect of the exchange rate system on both exports and imports. This is what is indicated by the value of the adjusted correlation coefficient in the correlation of imports with the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous era.
(3) The decrease in the volume of exports and imports indicates the negative impact of production, and this is demonstrated by the general decline in the GDP, as there was no significant effect of the exchange rate system on the GDP, as the correlation coefficient was 0.48 and the coefficient of determination (0.23).
(4) As a result of the decline in GDP, personal income decreased in general and fluctuated in some cases, which indicates the weak impact of the exchange rate system on personal income (the correlation coefficient was 0.54) and the coefficient of determination was 0.30.
(5) Also, the exchange rate system had a moderate correlation with inflation, the correlation coefficient was 0.75 and the coefficient of determination was 0.56, which indicates the presence of the influence of other factors on the inflation rate at a rate of 0.44. The results of the *F*-test indicated suitability of the regression line for the data. To the same extent, the result of the *t*-test was accepting the alternative hypothesis on the effect of the exchange rate system and accepting the alternative hypothesis on the effect of the exchange rate system on both GDP and personal income. This is what is indicated by the value of the adjusted correlation coefficient in the correlation of these variables with the variable under study when taking the gradual method to compare the correlation of the same variable with the independent variable in the previous era.

It is noted that the return to the flexible exchange system during the second era of the millennium led to a decline in exports, imports, GDP, and then personal income, and had a negative impact on increasing inflation rates.

Below are attachments to the tabular data for the results of testing the effect of the independent variable (exchange rate systems) by time period on the dependent variables (macroeconomic indicators (exports, imports, domestic product, personal income, and inflation rate) as shown in **Tables 3–8**.

Conclusion

This study aims to contribute to expand evidence on this significant topic using both descriptive and correlation approaches to evaluate the impact of exchange rate systems adopted in Sudan on macroeconomic variables during 1970–2019.

This study reached several results and recommendations, which we hope will encourage researchers to address this topic with further studies.

Results

After conducting the analysis of the relationship between exchange systems and the macroeconomic variables that were chosen, the study reached the following results:

(1) The fixed and stable exchange rate systems followed in Sudan were supportive of macroeconomic variables (exports, imports, domestic product, and personal income) and had a positive impact in reducing inflation rates.
(2) The systems of flexible exchange rates, floating, and complete liberalization of the exchange rate that were followed in Sudan had a negative impact and did not support the macroeconomic variables (exports, imports, domestic product, and personal income), and they also had a negative impact in increasing inflation rates.
(3) Exchange systems alone do not effectively affect the performance of macroeconomic variables unless there are integrated economic policies (price, monetary, financial, trade, etc.) that support production.
(4) Exchange systems alone do not effectively affect macroeconomic variables unless there is economic stability.

Recommendations

The study recommends the following:

(1) The necessity of following fixed or more stable exchange systems so that there will be positive and supportive effects on economic indicators.
(2) Failure to fully comply with the conditions of the International Monetary Fund and the World Bank, which include the complete liberalization of the exchange rate system and the successive devaluation

of the local currency. These are all measures that fall within the monetary and financial framework and do not stimulate real production, do not contribute to the diversification of the production base, and do not support added values.

(3) When applying the conditions of international institutions, it is necessary to take into account the exceptional state of the economy and then follow policies that support production.

(4) It is necessary to search for various other revenue sources that do not affect the production process, such as imposing taxes on real estate and unused lands, etc.

Periodic reports

1. Macroeconomic trends WB – Sudan reports
2. Reports of the Central Bank of Sudan
3. Central Bank of Sudan (2009) "Study documenting the exchange rate policy for the od (1956–2007 AD)."
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5. Report of the Central Bureau of Statistics – 2019
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Appendix

TABLE A1 | Fixing exchange rate variables and economic variables during 1970–1979.

INF	PI$	($B) GDP	($B) IMP	($B) EX	Local currency price to dollar	Years
40.311	450	9.03	1.75	0.90	0.40	79
30.192	397	7.67	1.17	0.61	0.39	78
0.1708	469	8.70	1.45	0.82	0.38	77
0.0167	390	6.98	1.34	0.78	0.37	76
0.2396	325	5.60	1.27	0.68	0.36	75
0.2616	277	4.60	0.95	0.58	0.35	74
0.1529	223	3.57	0.61	0.53	0.34	73
0.1355	186	2.88	0.48	0.46	0.34	72
0.0130	176	2.66	0.46	0.42	0.34	71
0.04032	166	2.44	0.40	0.40	0.33	70

Source: Macroeconomic trends WB.

TABLE A2 | Managed devaluated exchange rate variables and economic variables during 1980/1989.

INF	$PI	($B) GDP	($B) IM	($B) E	Local currency price to dollar	Years
0.6672	842	21.41	1.43	0.82	12	89
0.6470	569	14.37	1.18	0.58	10	88
0.2056	481	12.09	2.24	1.11	9	87
0.2445	408	10.09	1.30	0.75	8	86
0.4541	334	8.09	1.47	1.70	6	85
0.3415	440	10.45	1.60	0.82	5	84
0.3059	354	8.23	1.75	0.87	4	83
0.2571	369	8.32	2.26	0.92	0.50	82
0.2458	462	10.02	2.37	0.96	0.40	81
0.2535	429	8.95	1.73	0.79	0.37	80

Source: Macroeconomic WB.

TABLE A3 | Exchange rate variable (floating + liberalization crawling peg) and economic variables during 1990s.

INF	$PI	($B) GDP	($B) IMP	($) EX	Local currency price to dollar	Years
0.1717	339	10.68	1.81	0.83	2,516	1999
0.2462	366	11.25	1.71	0.75	1,994	1998
0.4717	389	11.68	1.46	0.62	1,576	1997
1.3282	308	9.02	1.25	0.56	1,246	1996
0.6838	484	13.83	1.36	0.69	578	1995
1.1540	459	12.79	1.27	0.60	400	1994
1.0138	327	8.88	0.64	0.38	216	1993
1.1762	263	7.03	1.01	0.37	132	1992
1.2358	1668	43.89	1.34	0.38	75	1991
0.6516	1302	33.64	0.88	0.50	20	1990

Source: Macroeconomic trends WB.

TABLE A4 | Exchange rate variable (managed floating and surplus of oil revenues) and economic variables during 2000–2009.

INF	$PI	($B) GDP	($B) IM	($) E	Local currency price to dollar	Years
0.1717	58.32	10.68	9.99	7.98	2,390	2009
0.2462	64.83	11.25	10.68	13.14	2,058	2008
0.4717	59.44	11.68	10.40	10.05	2,015	2007
1.3282	45.26	9.02	9.55	6.83	2,171	2006
0.6838	35.18	13.83	7.53	5.09	2,435	2005
1.1540	26.65	12.79	4.30	3.81	2,582	2004
1.0138	21.36	8.88	3.03	2.62	2,608	2003
1.1762	18.14	7.03	2.58	2.07	2,633	2002
1.2358	15.72	43.89	1.69	1.50	2,587	2001
0.6516	12.26	33.64	1.64	1.96	2,571	2000

Source: Macroeconomic trends WB.

TABLE A5 | Exchange rate system (Managed floating and scarcity of reserves) and economic variables 2010–2019.

INF	$PI	($B) GDP	($B) IMP	($) EX	Local currency price to dollar	Years
0.5099	748	32.34	2.66	5.09	62,000	2010
0.6329	770	32.33	3.22	6.08	48,000	2011
0.3235	3189	129.72	5.36	5.29	25,800	2012
0.1775	2614	102.94	6.49	5.10	19,600	2013
0.1691	2226	84.99	8.11	4.86	10,000	2014
0.3691	2076	76.82	7.34	8.29	8,900	2015
0.3652	1835	66.03	8.59	10.58	7,200	2016
0.3556	1797	63.20	8.18	7.98	6,500	2017
0.1810	1983	78.40	9.99	13.14	3,700	2018
0.1298	1706	74.15	10.15	10.05	2,900	2019

Source: Macroeconomic trends WB.