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Is the relationship between inflation and financial development symmetric or asymmetric? new evidence from Sudan based on NARDL

Yusra Ismail¹ and Mansur Masih²

Abstract

This study highlights the impact of inflation on financial development, using NARDL approach and the annual data available allow us to cover a period of 56 years. Sudan is used as a case study. The relationship between inflation and financial development remains an important issue in both theoretical and empirical literature because of its important implications on macroeconomic stabilization policies. The importance of the study comes from examining a developing country which is witnessing an economic deterioration generally and a hyper-inflation crisis that marked it as the second highest inflation rate in Africa in the 1st quarter of 2019. We test whether the relationship between the variables is symmetrical or asymmetrical in both short run and long run. Applying the autoregressive distributed lags model (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively, results confirm the presence of long run equilibrium relationship between inflation and financial development. Our findings tend to suggest that the long run relationship is symmetrical, while evidence is in support of asymmetrical short-run trade-off between the variables. Two main contributions are added to the previous literature. First, it applies a recent methodology that is Nonlinear ARDL (NARDL). Secondly it presents a new evidence from one of the high indebted poor countries-HIPC (Sudan) using data from 1961 to 2017.

Keywords: Inflation, financial development, non-linear ARDL

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1. Introduction:

The relationship between inflation and financial development is one of the most examined topics among different economies due to its important implications on macroeconomic stabilization. Large amount of literature has linked the investigation of inflation and financial development to the impact of financial development on economic growth. Several theoretical and empirical researchers have found that financial development promotes economic growth and have a significant effect in reducing inequality (Levine,1997). The focus of this paper is on the links between inflation and financial development as to whether the relationship between them is symmetrical or asymmetrical in the short and long run.

Financial development can be defined as “a situation where the quality, quantity moreover, the efficiency of financial intermediation services improve and all of individuals benefit from the comprehensive services of financial institutions” (Choong and Chan, 2011). Furthermore, both financial institutions and financial markets have a central role regarding the process of allocation of funds and savings of individuals to production; by reducing the information asymmetry, transaction costs and most importantly by reducing financial constraints (Khan, 2002). The importance of the financial institutions increases more when it comes to their effect on welfare through minimizing of macroeconomic shocks (Kim et al, 2010).

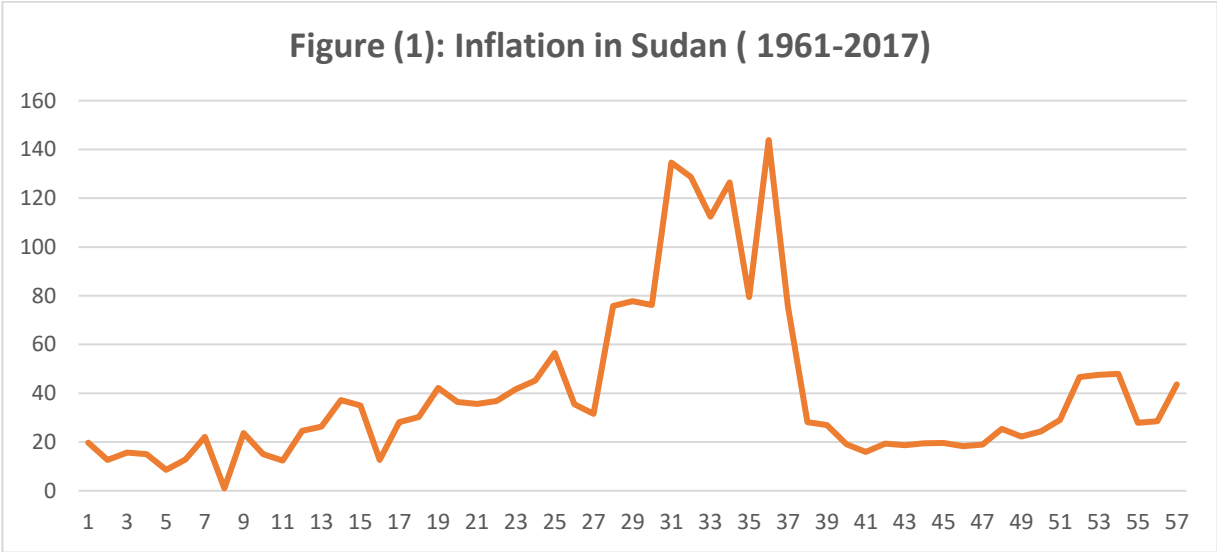
On the other hand, inflation has always been a concern in the studies as it creates uncertainty in the economic systems that may negatively affect economic growth. Generally, inflation is a disproportionate increase in the general level of prices along with an irregular increasing trend of prices in macroeconomic. It is a concern due to two main dangerous effects; first on the stability of any economy, and second that it hurts low-income individuals (Hanif and Batool, 2006). Studies show that inflation affects the relationship between the financial sector and growth. This reflects the importance of the issue of interaction between inflation and financial development, certainly in the developed countries (Ozturk and Karagoz, 2012). The direct effect of inflation on financial development is less taken into consideration in the previous studies than its effects on growth. Inflation is also seen as one of the main obstacles that negatively affect financial sector and economic growth as concluded in (Huybens and Smith, 1999), (Haslag and Koo, 1999), (Rousseau and Wachtel, 2000).

Theoretically, a combination of low inflation and financial sector development plays a crucial role in achieving sustained economic growth. This can be achieved by improving the intermediately role of the financial sector in two ways, between investors and savers, and between borrowers and lenders.

Generally, the previous literature had shown that the financial development has a positive effect on economic growth (Jung, 1986), (Roubini and Sala, 1992), (King and Levine, 1993), (Pagano, 1993). According to (Fischer, Sahay & Végh, 2002). Since inflation is a crucial issue in the developing countries, most of the empirical literature have been in line with the theory discussed above. For instance, (Akosah,2013), (Almalki & Batayneh, 2015) and (Mahyar ,2017) found negative long run relationship between inflation and financial development in Ghana, KSA and Iran respectively.

Sudan can be a good case for examining inflation. It is among 25 countries in the world that experienced occurrences of very high inflation crossing 100% growth rate per annum. A main reason for this is the various instability episodes in the country, specially from 1970-1990, 2012-2014, and 2017 until the moment which is resulted in a double-digit inflation rate. **Figure (1)** shows fluctuations of inflation in Sudan during the study period.

Hence, the significance of this study comes from examining an economy which is rich of various natural resources but is suffering from hyper-inflation crisis recently. By the end of March 2019, Sudan recorded the second highest inflation in Africa.



To summarize; the objective of this study is to re-examine the presence, nature and direction of the long run equilibrium relationship between inflation and financial development in Sudan. This research questions are in threefold as follows;

1. Is there a long run relationship between inflation and financial development (are they cointegrated)?

2. What is the nature of the relationship between inflation and financial development? Is it symmetric or asymmetric?

3. Which variable is the leader, and which is the follower? or which can be used to influence the other?

This study has two major contributions to the previous literature. Firstly, it employs the recent methodology of Nonlinear ARDL (NARDL) that enable us to test for symmetric or asymmetric relationship between our two focus variables. Secondly it presents new evidence from a developing country that is highly indebted poor country-HIPC (Sudan) using data from 1961 to 2017.

This paper confirms the long run equilibrium relationship between inflation and financial development (cointegration is found). This indicates that there is a theoretical relationship between the variables in the long run hence a variable can be used to predict the other. Results of NARDL approach, the study finds that the trade-off between inflation and financial development is symmetrical in the long run but asymmetrical in the short run. Applying Variance decomposition (VDC), inflation found to be exogenous while financial development is endogenous.

The following two chapters will explain inclusive results in both theoretical and empirical literature which motivates us to give a humble try and the results will tell. This paper is therefore an attempt to determine existence of the relationship between inflation and financial development, as well as its nature linear/non-linear or symmetric or asymmetric in Sudan. The fourth chapter will be a general guideline of our data and empirical methodology. While the fifth chapter will be discussion of results. Finally, conclusion and policy implication as the sixth and last part.

2. Theoretical underpinnings:

Conflicting predictions are found in theories about the effect of inflation on financial development. However, most of the work already done seems to suggest that increase in inflation impact financial developments negatively. The studies of (Huybens & Smith, 1999) concluded that an increase in the inflation rate will lead to frictions in credit market hence negative impacts on the financial sector performance. (Choi et al., 1996), and (Azariadis & Smith, 1996) highlight the fact that if inflation is high enough, returns on savings are reduced, the pool of borrowers is swamped, informational frictions become more severe, hence credit will witness scarceness in this situation.

(Schreft & Smith ,1997), (Boyd & Smith, 2000) and (Huybens & Smith ,1999) indicate the idea that economies with higher rates of inflation will have less efficient financial markets as a result of the higher interest rates that follow high rates of inflation.

Regarding why high inflation is responsible for the low level of financial development, (Altig, 2003) theoretically indicated that high inflation rates cause low returns to capital, thus the incentives to save and invest will eventually decrease. As a result, high inflation tends to obstruct long term financial contracting and therefore induces financial intermediaries to maintain very liquid portfolios. However, if inflation rate is high but predictable, there is no reason why real returns should be different. A more standard argument however is the fact that higher inflation is tied with greater inflation volatility, and hence greater uncertainty. The problem is particularly heightened when collateral is required for the efficient functioning of borrowing and lending markets. With disincentive to save due to high inflation, too little saving inhibits the accumulation of collateral and thereby impedes growth enhancing financial intermediation (Smith, 2003).

On the other hand, the following studies concluded a positive relationship between inflation and financial development. According to (Mundell, 1963) and (Tobin, 1965), portfolio allocations are influenced by inflation due to low returns on capital, leading to improvements in investment activities. This situation spurs growth process in the economy. In addition, English (1999) found positive effect of inflation on financial development as households tend to substitute purchased financial services for holding real money balances, boosting the provision of financial services. Other studies like (Roubini & Sala-i-Martin, 1992), (King & Levine, 1993), (Rousseau & Watchel, 1995), (Haslag and Koo, 1999), (Levine, Loyaza, & Beck, 2000) also found strong positively correlation between our two highlighted variables. Specifically, using a large cross section of 98 countries from 1960 to 1985, (Roubini et al, 1992). Their argument was that inflation matters in several theoretical growth models as it alters the returns on money which can have real sector consequences. This is seen as a possible channel by which inflation affects growth, through the financial sector.

(Kim, Lin and Suen, 2010) concluded mixed results. They found evidence of a higher negative effect on the long run of inflation on financial development, yet a positive short run effect was found; demonstrating that higher inflation stimulates financial activities in the short run.

Since the above studies concluded contradictory theories, hence the relationship between inflation and financial development can be linear or non-linear, or symmetric or asymmetric. Thus, the following chapter will give a summary of empirical literature which may be useful for specifying the relationship between the two variables.

3. Empirical review:

The focus of the following empirical literature is on the long-term equilibrium relationship but not between our two focus variables (inflation and financial development). They examined mostly financial development or economic growth but with other variables focused and not inflation like our paper focus. In other words, and to the best of our knowledge, there is no literature yet that have particularly examined inflation and financial development using NARDL, hence we will give a humble attempt to fill the explained literature gap.

Highlighting inflation and financial development, most of the literature examined causality and conclude that financial development is lead by inflation particularly in the developing countries. To some extent, no empirical studies confirmed linear relationship between inflation and financial development. Hence, non-linear findings will be discussed below. First, literature of asymmetry conclusions will be discussed, then symmetry and finally non-linear studies.

(Phiri,2015) examined the relationship between financial development and economic growth in South Africa form 1992-2013. The author applied M-TAR approach (momentum threshold autoregressive) which allows for threshold error-correction (TEC) modelling and Granger causality analysis between the variables. Author concluded an asymmetric and non-linear relationship between the two focus variables in the long run. (Ajaza, Nain & Kamaiah,2016) applied Non-linear ARDL to examine the dynamic relationship between inflation and openness from 1970 -2014 in India. They found asymmetry in the relationship between openness and inflation in both in short-run and long-run. (Grier, Henry & Olekalns,2004) concluded asymmetry of uncertainty (represented by growth volatility and inflation volatility) on average rates of output growth and inflation in U.S.A. Their suggested that increased growth uncertainty is associated with significantly lower average growth, while higher inflation uncertainty is significantly negatively correlated with lower output growth and lower average inflation. Both inflation and growth display evidence of significant asymmetric response to positive and negative shocks of equal magnitude.

(Demir & Hall,2017) studied the relationship between financial structure and economic development for Germany, USA, France and Turkey for the period from 1989 -2012. Nonlinear Autoregressive Distributed Lags (NARDL) was employed. They found symmetric long run relationship between their focus variables. They supported their findings with ‘new structuralism’ theory on the linkages between financial structure and the stage of development for these four economies. Moreover, (Qamruzzaman & Jiangno,2018) using NARDL and quarterly data for the

period 1975-2016. Results indicated a long-run symmetric relationship and mixed results in the short run regarding the relationship between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka. They conclude that financial innovation boosts economic growth in the long run by stimulating financial service expansion, financial efficiency, capital accumulation, and efficient financial intermediation, which are essential for sustainable economic growth.

On the other hand, (Haffjee & Masih, 2018) highlighted the issue of financial development and income inequality in South Africa. NARDL was applied. However, authors could not find neither short nor long-run asymmetry in the relationship between financial development and income inequality in the case of South Africa.

The following studies highlighted non-linearity between inflation and financial development as 1% change in inflation won't change financial development with the same amount. This implies that there is a direct but non proportional relationship between inflation and unemployment. In other words, a x% change in inflation won't cause the financial development to change by the exact proportion.

(Bittencourt, 2011) tested for linearity in Brazil (1985-2004) using mixed methodology of time series, panel time series and panel data techniques and found negative non-linear relationship as in Brazil along the study period and considering the overall macroeconomic performance and the transition from dictatorship to democracy, inflation -as a proxy of macroeconomic performance, arises obviously hence had an impact on the deterioration of Brazilian financial sector..(Odhiambo, 2012) ;using different dataset and econometric techniques confirmed significantly negative non-linear effects of high inflation on financial sector development. With a spotlight on banking sector and stock market, panel data for 15 Latin American countries (1978-2003); (Al-Nasser,2012) concluded the same results for inflation on banking sector and stock market development.

Since theoretical and empirical literature could not bring an inclusive result of our main issue, the issue remains not resolved. Using both ARDL and Non-Liner ARDL, this paper is a humble examination of whether the relationship between inflation and financial development is negative or positive, linear or non-linear and symmetric or asymmetric. Researches on Sudan are rather limited.

4. DATA & METHODOLOGY:

4-1: Data & variables:

This data of our study is on inflation and financial development of Sudan from 1961 to 2017. I have used 57 years data. Our focus variables are Inflation and financial development. I intent to examine whether the variables have long run equilibrium relationship and the nature of the relationship (whether linear or non-linear and symmetric or asymmetric). Yet, two control variables were included which are theoretically related with inflation and financial development (Akosah, 2013). These variables are the Gross Domestic Product Growth (GGDP), and real exchange rates. Summary of the variables used, and their sources are presented in **Table 2**.

Table (1): Descriptive statistics table

<i>Variable</i>	<i>Total observations</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Mean</i>	<i>Standard deviation</i>
GDP growth	57	23.6	.65	10.91763	5.26855
Inflation	57	143.85	1	41.3085	33.25445
Financial development	57	13.96	1.62	8.660339	3.633074
Exchange rates	57	6.6751	0	1.303453	1.812112

Table (2): Summary of the Variables

<i>Variable</i>	<i>Measure</i>	<i>Nature of the variable</i>	<i>Source</i>	<i>Symbol</i>
Gross Domestic Product Growth	Annual percentage growth rate of GDP at market prices based on constant local currency.	Control	Thomson Reuters DataStream	LGGDP*/DGGDP**
Inflation	Consumer price index reflecting the annual percentage change in the cost of living to the average consumer	Focus	Thomson Reuters DataStream	LINF/DINF
Financial development	Domestic credit as a percentage of GDP (bank-based)	Focus	Thomson Reuters DataStream	LFND/DFND

Exchange rate	Exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. (Sudanese Pound relative to USD)	Control	Thomson Reuters DataStream	LEXCH/DEXCH
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L: logged form / D: differenced form.

4.2 Empirical methodology:

We have employed standard time series techniques and more recent techniques of autoregressive distributed lags (ARDL) and Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively. Then proceed with the Granger-causality testing to examine the causality chain between inflation, financial development GDP growth, official exchange rate and trade openness.

4.2.1 Unit-root test:

It is necessary to perform unit root test before testing for the existence of long run equilibrium relationship (cointegration). The unit root test at level and differenced form aims to test for stationarity. In other words, variables are stationary if their mean, variance and covariance are constant while a non-stationary series has an infinite variance, permanent shocks and its autocorrelations tend to be unity. This study will use Augmented Dickey-Fuller - ADF (Dickey and Fuller, 1979), Phillips-Perron - PP (Phillips and Perron, 1988) and KPSS (Kwiatkowski et al., 1992) tests to test for stationarity. ADF test accounts for only autocorrelation, while the PP test accounts for both autocorrelation and heteroskedasticity. It is necessary to perform stationarity test as some cointegration methods such as Johansen test are sensitive to the stationarity of the variables. Johansen is only applicable when the variables are non-stationary.

4.2.2 Determination of the order (lags) of VAR model:

Before performing Johansen test (Johansen, 1991) of cointegration, the number of lags must be specified in the VAR model. This involves determination of the order or lags of the model through Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). The former emphasis is on predicting the best order of lags, favours large value of likelihood and hence it is less concerned of overparameterization. However, the SBC tends to lower the number of lags trying to avoid over-parameter.

4.2.3 Cointegration:

Cointegration is defined as a test of presence or absence of long run equilibrium relationship between the variables. When the variables are cointegrated, the conclusion is that the relationship between them is theoretical and not spurious. It also means that variables contain information to predict one another. Several cointegration tests are applied. First, the Engle Granger test (Engle and Granger, 1987) is used. Johansen cointegration test is also applied. The contradiction in unit root results makes ARDL a more appropriate cointegration test to be performed. Hence, ARDL and Nonlinear ARDL approaches provided by Pesaran et al. (2001) and Shin et al. (2014) will be applied. The idea behind NARDL is to allow us to see if the relationship between inflation and financial development is linear or non-linear, symmetric or non-symmetric in both short run and long run relationship. It's worth noting that conventional regression neither ARDL cannot answer our core question, thus NARDL is the most appropriate techniques to be used.

4.2.4: Causality:

Due to the importance of our title, we provide causality tests for the purpose of giving humble policy recommendations to the policy makers. Vector Error Correction Model (VECM) tell us about the absolute endogeneity/exogeneity among the variables. Variance Decomposition (VDC) is more important for the Sudanese policy makers because it determines the relative endogeneity/exogeneity, in other words which variable is most endogenous (weak or highly dependent) and which is most exogenous (strongly independent). Impulse response function and Persistence Profile are also performed. The former shows the impact of one variable shock on other variables' behavior while the latter is a wide system shock.

5. RESULTS & DISCUSSION:

5.1 Unit root-test:

The three tests below present different results on variables' stationarity. ADF test shows majority of the variables are non-stationary at level form but only GGDP has mixed results. Inflation and exchange rates found to be non-stationary at differenced form contrasting to PP that concluded stationarity for all variables. Yet, PP give conflicting results of stationarity for inflation and GDP growth at level form. The same conflict applies for KPSS in the differenced form as all variables appear to be stationarity. Due to the mixed results, this study compelled to move to the ARDL co-

integration test that was introduced by Pesaran and Shin (1999) later extended by Pesaran et al., (2001) that can comprise of both I(0) and I(1). PP has been chosen to proceed to cointegration as all variables are stationary in the differenced form. The results for the three tests, ADF, PP and KPSS are presented in **Table 3**, **Table 4** and **Table 5** respectively.

a) ADF: Table 3-A

LOG FORM	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT	
	LGGDPP	ADF(4)=SBC		-63.9972	-3.1627	-3.3510	Stationary
		ADF(1)=AIC		-58.3375	-5.6666	-3.4796	Non-Stationary
	LEXCH	ADF(5)=SBC		-30.5616	-1.4070	-3.5550	Non-Stationary
		ADF(5)=AIC		-24.8257	-1.4070	-3.5550	Non-Stationary
	LINF	ADF(5)=SBC		-58.3706	-2.0310	-3.3636	Non-Stationary
		ADF(5)=AIC		-50.6433	-2.0310	-3.3636	Non-Stationary
	LFND	ADF(1)=SBC		4.3640	-1.4469	-3.4796	Non-Stationary
		ADF(4)=AIC		10.5694	-2.7090	-3.3510	Non-Stationary

Table 3-B

1ST DIFF. FORM	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT	
	DGGDP	ADF(1)=SBC		-70.5525	-6.9832	-2.8506	Stationary
		ADF(1)=AIC		-67.6844	-6.9832	-2.8506	Stationary
	DEXCH	ADF(5)=SBC		-30.6063	-1.5848	-2.8128	Non-Stationary
		ADF(5)=AIC		-25.7021	-1.5848	-2.8128	Non-Stationary
	DINF	ADF(5)=SBC		-57.8174	-2.5571	-2.9167	Non-Stationary
		ADF(5)=AIC		-51.1253	-2.5571	-2.9167	Non-Stationary
	DFND	ADF(1)=SBC		5.0263	-3.7667	-2.8506	Stationary
		ADF(1)=AIC		7.8943	-3.7667	-2.8506	Stationary

b) PP test:

Table 4-A

LOG FORM	VARIABLE	VALUE	C.V.	RESULT
	LGGDP	-5.7516	-3.4064	Stationary
	LEXCH	-.83284	-3.5292	Non-Stationary
	LINF	-4.3466	-3.4064	Stationary
	LFND	-1.6131	-3.4064	Non-Stationary

Table 4-B

1ST DIFF. FORM	VARIABLE	VALUE	C.V.	RESULT
	DGGDP	-17.6796	-2.9383	Stationary
	DEXCH	- 4.6347	- 3.0274	Stationary
	DINF	- 16.0718	- 2.9383	Stationary
	DFND	- 5.7355	- 2.9383	Stationary

KPSS:

Table 5-A

LOG FORM	VARIABLE	VALUE	C.V.	RESULT
	LGGDP	0.10005	0.16754	Stationary
	LEXCH	0.13050	0.14645	Stationary
	LINF	0.12249	0.16754	Stationary
	LFND	0.10753	0.16754	Stationary

Table 5-B

1ST DIFF. FORM	VARIABLE	VALUE	C.V.	RESULT
	DGGDP	0.12263	0.38345	Stationary
	LEXCH	0.20829	0.38756	Stationary
	LINF	0.1135	0.38345	Stationary
	LFND	0.10753	0.38345	Stationary

5.2 Determination of the order (lags) of VAR model:

Using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC), the chosen or the preferred lag is (1). Table (6) presents the results of the order of lag determination.

Table 5: VAR lag order

SELECTION CRITERIA	LAG ORDER	VALUE
Akaike Information Criterion (AIC)	1	-85.0440
Schwarz Bayesian Criterion (SBC)	2	-107.6691

5.3 Cointegration

5.3.1 Engle-Granger cointegration test

For this test; the null hypothesis is that there is no cointegration. Decision of failing to reject the null is made if the C-value is more than the T-statistics. **Table 7** below shows that the critical value of **-4.4568** is more than the T-statistics, hence we fail to reject the null hypothesis. This test concludes that there is no relationship between inflation and financial development in the long run. Yet, this method has a limitation of not being able to identify the number of cointegrating vector. It can only show presence and absence of cointegration. Therefore, we proceed to Johansen test.

Table 6: E-G cointegration test

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.4085	-9.1254	-10.1254	-10.8583	-10.3684
ADF (1)	-1.4671	-9.0084	-11.0084	-12.4741	-11.4942
ADF (2)	-1.2806	-8.9353	-11.9353	-14.1339	-12.6641
ADF (3)	-1.2317	-8.9302	-12.9302	-15.8617	-13.9019
ADF (4)	-1.3918	-8.6116	-13.6116	-17.2759	-14.8262

95% critical value for the Dickey-Fuller statistic = **-4.4568**

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

5.3.2 Johansen cointegration test

Like Engle Granger, the null hypothesis is that there is no cointegration. When the C-value is more than the T-statistics, we fail to reject the null hypothesis of no cointegration and hence we conclude the variables are cointegrated. In **Table 8** below, the critical value of for $r=1$ and is less than the T-statistics thus, we reject the null hypothesis. We conclude that there is a relationship between inflation and financial development in the long run.

Johansen test has a limitation which is sensitivity to the number of lags. Furthermore, it requires only non-stationary variables and suffers from pre-test bias towards failing to reject the null hypothesis. We fail to reject the null 95% of the time at 5% significant level. Thus, we proceed to ARDL. This test assumes both linearity and symmetric between the variables.

Table 7: Johansen's cointegration test

- Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Results
$r = 0$	$r = 1$	37.7900	31.7900	29.1300	1 Cointegration
$r \leq 1$	$r = 2$	19.7664	25.4200	23.1000	
$r \leq 2$	$r = 3$	11.4721	19.2200	17.1800	
$r \leq 3$	$r = 4$	7.2102	12.3900	10.5500	

- Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Results
$r = 0$	$r \geq 1$	76.2927	63.000	59.1600	1 Cointegration
$r \leq 1$	$r \geq 2$	38.4487	39.3300	39.0400	
$r \leq 2$	$r \geq 3$	18.6823	25.7700	23.0800	
$r \leq 3$	$r \geq 4$	7.2102	12.3900	10.5500	

5.3.3 Autoregressive distributed lags (ARDL):

Unlike Johansen, ARDL does not suffer from pre-test biases. This test suits our data sample which is from 1961-2017 because it accommodates both stationary I (0) and non-stationary variables I (1). Alike the previous cointegration tests, the null hypothesis is “no-cointegration”. Our F-statistic indicates that we can reject the null since it the upper bound of the critical values is less than the F-statistic, thus we conclude presence of cointegration and that the variables are moving together in the long run. As shown in the table below, F-statistics is more than the upper critical bound for financial development, inflation and exchange rates. If at least, one variable is adjusting to bring long run equilibrium, the variables are cointegrated. It makes economic that increase in inflation can reduce financial development. GDP Growth (GGDP) is essential also to reach higher levels of financial development by the increase in overall goods and services produced in an economy. Raise in GDP growth can increase credits to private sector as of the relatively positive economic situation and future expectations. Inflation, however, can be increased also if GDP increased only through spending (C) which may affect the exchange rates negatively (depreciate) and reduce financial development.

All variables found to be cointegrated, but GDP growth and inflation were the respectively significant ones if we look at their p-values. **Table 9** shows the results of ARDL cointegration test in the short run (ECM).

Table 9: ARDL Cointegration- ECM

Variable	F-statistics	P-value	Critical Lower Bound	Critical Upper Bound	Conclusion	Significance level
DGGDP	4.4849	[.009]	3.6071	4.9005	cointegration	5%
DEXCH	4.4739	[.572]	2.9488	4.0882	Cointegration	10%
DINF	2.7811	[.086]	3.6071	4.9005	Cointegration	5%
DFND	6.5648	[.007]	3.6071	4.9005	Cointegration	5%

The next step is presenting the long run ARDL coefficients. **Table 10** below shows the results of ARDL long run coefficients. Using (AIC), all inflation and GDP Growth and exchange rates are found to be insignificant, hence they are exogenous. Because of the insignificant p-values, we cannot reject the null of no cointegration in the long run using ARDL test which is a good justification to preform NARDL test.

Table 10: Long run coefficients – LFND ³

Regressor	Coefficient	Standard Error	P-value
LINF	.049093	.096912	[.617]
LGGDP	-.0026783	.050132	[.958]
LEXCH	.0064364	.014066	[.651]

Both ARDL and Johansen assume both linearity and symmetric between the variables which why they are biased, therefore we proceed to NARDL because it does not suffer from such limitation. Since the focus of this paper is to examine symmetric or asymmetric between inflation and financial development, we proceed to NARDL test.

³ At 95% confidence level, F statistic= 7.2276, upper C.V = 4.9005 and lower C.V = 3.6071. Hence, we have cointegration in the long run although the variables are insignificant. However, FND is found significant (endogenous) which is consistent with our results for VDC below.

5.3.4 Non-linear ARDL

Unlike Johanson & ARDL, NARDL does not assume linearity and stationarity between the variables. Non-linear ARDL (NARDL) technique is used to test the relationship between the focus variables. (Hoang & Lahiani & Heller, 2015) explained that NARDL is superior because it accounts for both short and long run asymmetry and relax the requirement of variables to have the same order of integration. The null hypothesis is no cointegration. We can reject the null if the F-statistic is above the upper bound of the critical value (C.V). Since the number of observations is 224, we can use the asymptotic critical values from Pesaran et al. (2001). Our results below reject the null, hence we have cointegration. Table 11 below of NARDL cointegration results, shows that the F-statistics is above the upper bound of the critical value at 5% significance level for Pesaran critical values. This indicates presence of long run equilibrium relationship between inflation and financial development.

Table 11: NARDL cointegration results

Variable	F-statistics	Critical Value Source	Critical Value (%)	Critical Lower Bound	Critical Upper Bound	Conclusion
LINF	7.4072	Pesaran et al. (2001)	5%	3.75	4.85	Cointegration

Table 12 below shows the results of short run and long run asymmetry from the Wald test. The following model is general form of NARDL model introduced by Shin et al., (2011).

$$\Delta FND_t = \beta_0 + \beta_1 FND_{t-1} + \beta_2 INF_{t-1}^+ + \beta_3 INF_{t-1}^- + \sum_{i=1}^p \varphi_i \Delta FND_{t-i} + \sum_{i=0}^q (\theta_i^+ \Delta IWF_{t-i}^+ + \theta_i^- \Delta INF_{t-i}) + u_t$$

Where FND is financial development, INF is inflation and p and q are lag orders⁴. NARDL will decompose non-performing loans into its positive ΔNPL_{t-i}^+ and negative ΔNPL_{t-i}^- partial sums for increases (+) and decreases (-).

The null hypothesis of NARDL test shows that the relationship between the variables is symmetry in long and short term, while the alternative hypothesis shows that there is an asymmetry.

⁴ lag order 2 has been used here in order to find cointegration.

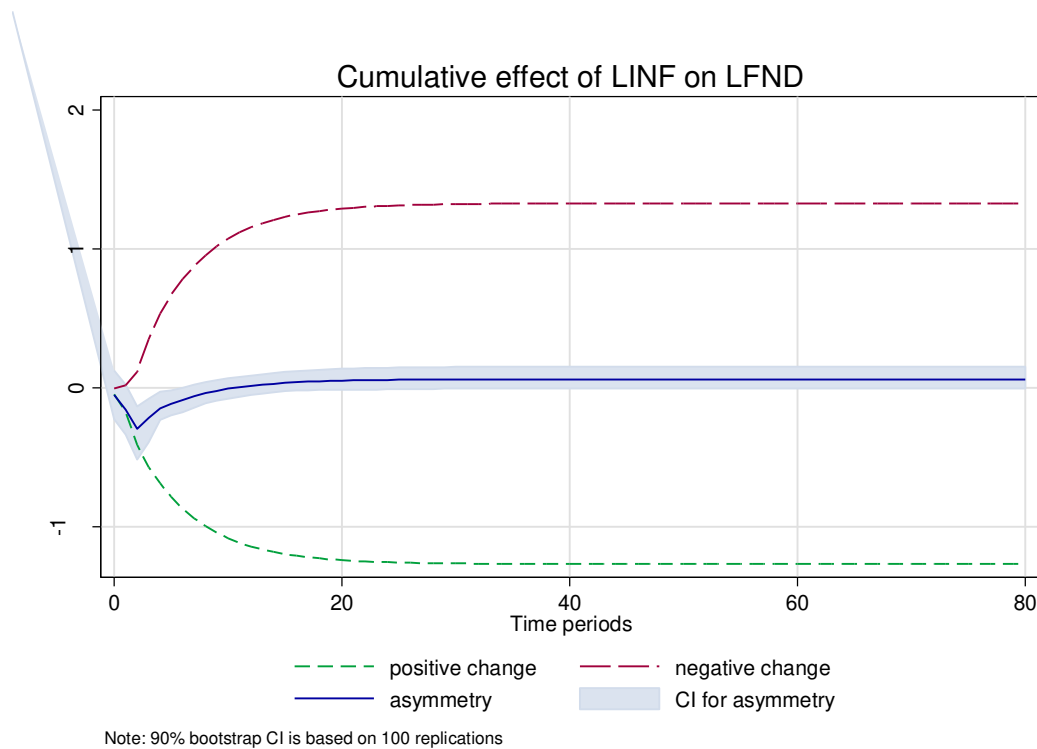
Results in the table below show the presence of long run symmetry and short run asymmetry, where only in the latter case, the P-value is significant (.012). The trade-off between inflation and financial development, in the short run is not the same in terms of upward and downward scenarios. The cumulative effect of inflation and financial development is shown in **Figure 2**. As highlighted in blue and due to short run asymmetry, some of the lines fall outside the symmetry area (highlighted in blue). A positive change (increase) in inflation will deteriorate financial development as highlighted in green, while a negative change (decrease) in inflation will improve the financial development as highlighted in red.

Our results from the Wald test of short run and long run asymmetry; shows presence of long run symmetry and short run asymmetry. P-value in **Table 12** is significant only in the short run. As a result, in the short run the trade-off between inflation and financial development is not at the same magnitude (not in the same in upward and downward scenarios). A short run asymmetry; the result can be feasible, as when economic conditions in Sudan are heavily affected by inflation hikes in view of no clear policy adopted by the authorities, i.e. CBOS and MOF⁵ to curb the said hikes, this would in turn negatively affect financial institutions lending to the private sector. Whereas symmetric in the long run, implies that if the authorities; mainly CBOS can actively play its key role and stick to its mandate with regards to price stability, or reducing inflation (should focus to maintain low inflation) to reasonable targets (One digit inflation) .This might provide financing opportunities to private sector which in turn positively lead to the financial development. **Figure 3** of the cumulative effect of expected inflation and expected unemployment. As it can be observed, due to short run asymmetry, some of the lines fall outside the symmetry area highlighted in blue.

Table 12: NARDL symmetric/asymmetric results

Independent Variable: Inflation	F-Statistics	P-value	Conclusion
Long run	1.082	.304	Symmetry
Short run	6.942	.012	Asymmetry

⁵ Ministry of Finance.



5.5 Vector error correction model (VECM)

This test aims to distinguish between the variables in terms of absolute endogeneity and exogeneity. A p-value of less than 5% would indicate that the variable is endogenous since the null hypothesis of exogenous variable is rejected. **Table 13** shows results from VECM where both inflation and financial development are endogenous, while only exchange rate is exogenous. This makes economic sense since for most governments, inflation can be controlled by instruments of monetary policies, but exchange rates are determined globally. VECM does not show the relative endogeneity and exogeneity of the variables. As a result, I have performed VDC (Variance Decomposition), To know which variables is the most endogenous.

Table 13: VECM: dependent variable: LFND

Regressor	Coefficient	Standard Error	P-value	Conclusion
LINF	.066672	.018276	[.035]	ENDOGENOUS
LEXCH	-.049876	.036860	[.186]	EXOGENOUS
LGGDP	-.26531	.057917	[.000]	ENDOGENOUS

5.6 Variance decompositions (VDC)

In this step, we decompose the variance of the forecast error of a variable into proportions attributable to either shocks or innovations in each variable in the system including its own. The most exogenous variable is the variable which can be explained most by its own shocks. The study provides both generalized and orthogonalized variance decomposition which yield similar results. However, generalized approach is deemed to be better since it is not affected by the order of variables and doesn't assume that when one variable is shocked others are switched off. Results of variance decomposition are presented in **Tables 14-15**. GDP Growth is the most exogeneous followed by inflation, then exchange rates and finally financial development. It is obvious that results of VECM and VDCs are not consistent, hence I choose VDCs because it has the following advantages over VECM which are: first, VDCs is a beyond sample period forecasting, second it shows clearly the pecking order of the variables in terms of relative exogeneity/ endogeneity and can be more useful for policy makers.

Table (14): Generalized Variance Decomposition (horizon 10)

Horizon 10	LGGDP	LINF	LFND	LEXCH
LGGDP	96.35%	0.52%	3.02%	0.11%
LINF	2.08%	90.96%	3.73%	3.23%
LFND	2.98%	70.60%	23.65%	2.78%
LEXCH	0.61%	53.75%	0.71%	44.92%
Exogeneity	96.35%	90.96%	23.65%	44.92%
Ranking	1	2	4	3

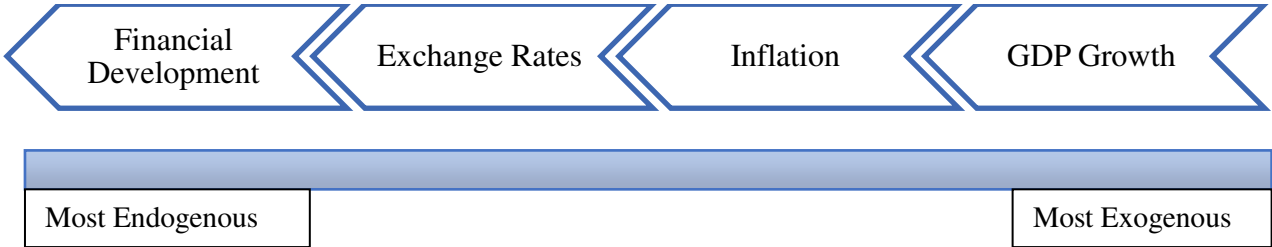
Table (15): Orthogonalized Variance Decomposition (horizon 10)

Horizon 10	LGGDP	LINF	LFND	LEXCH
LGGDP	97%	3%	0%	0%
LINF	2%	96%	1%	0%
LFND	3%	78%	19%	0%
LEXCH	1%	64%	3%	32%
Exogeneity	97%	96%	19%	32%
Ranking	1	2	4	3

The unique case of the Sudanese economy indicates that GGDP (GDP growth) has been persistent as the most exogenous variable over the study period. Since $GDP = C + I + G + (X - M)$; where 'C' represents all private consumption. 'G' is the sum of government spending. I is the sum of all the country's investment, including businesses capital expenditures and NX is the nation's total net

exports, calculated as total exports minus total imports ⁶. Thus, lack of control can be explained through some of GDP components. Majority of investments in Sudan are foreign investment which are poorly regulated by the Sudanese government. Exports also are not controlled by the government since it depends on influence of outside factors like technology transfer. If This latter factor is exogenous, exports can also be exogenous as well.

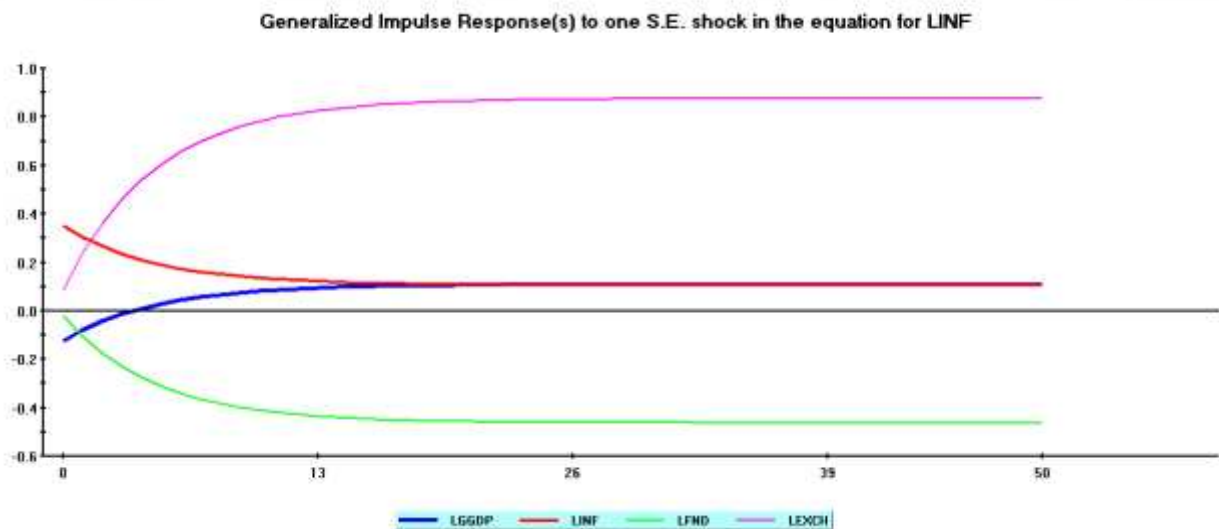
Inflation and exchange rates are in the middle since both are affected by changes in GDP Growth (GGDP). The former is negatively impacted by GGDP which is proven for the Sudanese economy as CPI has been increasing significantly from 1989 until the moment while GGDP was fluctuating or almost not growing. The main reasons for the increase of inflation are instability of the economy as a result of the civil wars in the southern and western parts, U.S economic sanctions on Sudan which had ended in October 2017, lastly; the inflation dramatically jumped after the secession of the Southern forming the republic of South Sudan in 2012 which negatively affected the GGDP due to the loss of southern oil which counted for 95% of Sudan’s exports and more than half of government’s revenue. Exchange rate is positively influenced by GGDP as theoretically; the increase in real GDP will lead to appreciation in any local currency. Financial development is found to be the most endogenous or most dependent variable which makes sense because it is highly and negatively affected by the growing inflation rates. The reason can be because of the increase in operating costs of financial intermediaries (specifically banks) which reduces the return of all financial assets and increase credit market frictions as argued by (Akinkoye et al., 2015).



⁶ <https://www.investopedia.com/terms/g/gdp.asp>

5.6 Impulse response function (IRF)

IRF gives a better understanding of VDC's results but in graphical terms. It determines the effect of one variable shock on other variables. **Figure 3** below shows the IRF when inflation is shocked⁷. However, it seems that the variables might take more than 50 years to come to equilibrium.

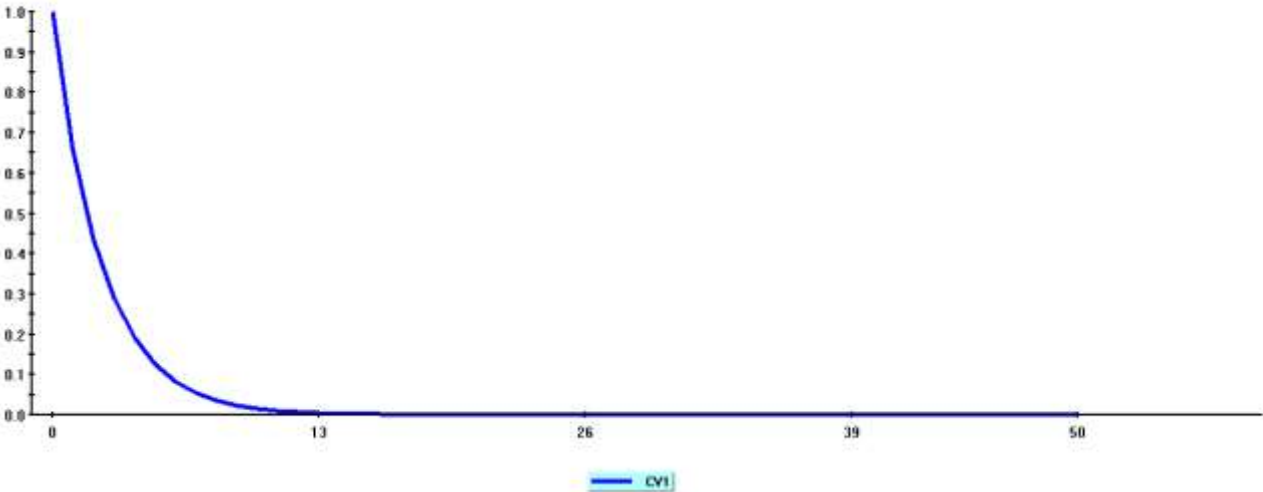


5.8 Persistence profile of the effect of a system wide-shock:

Contrasting to the previous step (IRF) that use a variable-specific shock to see the impact on other variables on the system, Persistence Profile (PP) uses a system-wide shock on the long-run relations between the variables in order to estimate how long it would take to get back to equilibrium if the entire co-integrating equation is shocked. **Figure 4** below shows that when the whole co-integration equation is shocked, all variables will come to equilibrium after 12-13 years.

⁷ No much response occurred when each of the other variables were shocked, hence we chose to proceed with results of inflation.

Persistence Profile of the effect of a system-wide shock to CV(s)



CONCLUISON & POLICY RECOMMENDATIONS:

This study examines the presence and nature of the long run equilibrium relationship between inflation and financial development using evidence from Sudan which has been marked as the second highest inflation rate in the 1st quarter of 2019. The techniques used are standard time series techniques and more recent techniques of autoregressive distributed lags model (ARDL) & Nonlinear ARDL approaches proposed by Pesaran et al. (2001) and Shin et al. (2014) respectively. The significance of this study can be in threefold. First contributing to the literature by employing recent technique of NARDL, also and to the best of my knowledge, it is the first study in both examining the symmetric or asymmetric relationship between the two focus variables, also form a country considered as a heavily indebted poor country (HPIC).

Referring to the objectives of the study, three key findings have been stated:

1. Using Johansen and NARDL tests there is a long run equilibrium relationship between inflation and financial development which indicates that the variables are cointegrated. ARDL approach concluded cointegration only in the short-run and absence of long run cointegration. NARDL results are preferred because cointegration has been found, it is the most recent technique and the focus on this paper
2. Using NARDL approach, the study finds that the relationship or the trade-off between inflation and financial development is symmetrical in the long run but asymmetrical in the short run.
3. Applying Variance decomposition (VDC) which has been preferred over VECM, results found that financial development is lead by inflation. This is parallel with (Akosah ,2013), (Sanusi K.A., Meyer D., Ślusarczyk B., 2017). It is obvious that results of VECM and VDCs are not consistent, hence VDCs is preferred because of its two advantages over VECM which are ;it is a beyond sample period forecasting and it shows clearly the pecking order of the variables in terms of *relative exogeneity/ endogeneity* and can be more useful for policy makers.

The results are robust to majority of the cointegration methods. They have significant policy recommendation particularly for the governments and central banks of the highly corrupted

and indebted economies. The policy recommendations are as follow;

- 1- Since most of the developing economies suffer form high levels of corruption, “spending “should be monitored and restricted to productive plans only. By ensuring an effective fiscal policy, a 1% increase in GDP (reducing budget deficit and borrowing rates form central banks) can be seen as a healthy increase, consequently, exchange rated can be improved.
- 2- CBOS should be cautious of its monetary policies implementation (money supply) because it can have more serious damages to the banking sector and the economy. As inflation has high cost on the economy, CBOS and Sudanese government should consider macroeconomic stabilization as the main objective of their monetary policy. Controlling inflation can be the first step in managing other issues such as liquidity, which leads to better allocation of credits, higher development of the financial sector and the economy as well.
- 3- The results showed an *asymmetric relationship* between inflation and financial development in the short run which indicates the levels of stimulation and shrinking of monetary policy must not be equaled. In other words, they should be changing in different upwards and downwards. Suitable monetary policies are crucial to control the inflation hikes.

Limitations of the study: Personal acknowledgment that results might be biased to the nature of the economy and variables chosen. Results might have been different if trade openness was included. Sudan to some extent; suffer from availability of macroeconomic data which was the justification for using the variables of this study. I also acknowledge that monthly data would have been better if they were available. Future researches should focus on providing evidence for magnitudes of asymmetric in short & long run in order to bring strong recommendations for economy stabilization.

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