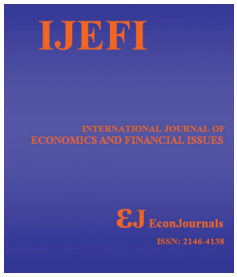

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An Asymmetric Analysis of the Relationship between Openness and Inflation in Côte d'Ivoire

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ABSTRACT

This study investigates the existence of an asymmetric relationship between openness and inflation in Côte d'Ivoire from 1970 to 2015. For that purpose, a Non-linear Autoregressive Distributed Lags model is implemented. The KOF Globalization index is used to measure openness. We decompose the index in negative and positive partial sums and in quantiles partial sums. The results suggest both short and long runs asymmetries in the relationship between openness and inflation in Côte d'Ivoire. In the long run, inflation strongly responds to a decrease in openness than to an increase in openness. In the short run, the asymmetric effect of openness on inflation is time-specific. Furthermore, a positive and significant effect of openness on inflation is found for low values of openness. For median values of openness, the effect on inflation is negative. For high values of openness, the effect on inflation is positive but non-significant.

Keywords: Asymmetry, Inflation, Openness
JEL Classifications: C01, E31, F41

1.INTRODUCTION

Recent trends in the developing world and in African economies show an increasing interest in outward policies such as a regional integration increasingly increased, the existence of regional groupings, trade agreements and liberalization of trade among others. In Côte d'Ivoire, openness has earlier been included in growth and development strategies and fast integration has been observed over the years. According to Keho (2017), the effect of trade openness Côte d'Ivoire's economic growth is positive. There are valid reasons to believe that Côte d'Ivoire's openness affects other macroeconomic variables.

With a specific view to inflation, the question whether or not openness helps in reducing inflation is well documenting in the literature. Seminal theoretical works have been conducted by Iyoha (1971), Romer (1993), and Terra (1998) among others. Since then, the empirical literature has been devoted to unravel the link between inflation and openness.

Empirical studies have been inconclusive regarding the effect of openness on inflation. There may be two possible reasons for those mixed results. The first one could be the presence of non-linearity between openness and inflation. The second one could be related to the proxy used to measure openness. This paper contributes in filling the gap in the empirical literature related to the analysis of the asymmetric effects of openness on inflation. Asymmetry is a type of non-linearity. That said, economic variables are subject to non-linearity, particularly to asymmetry. Numerous empirical studies relied on the Shin et al. (2014) non-linear autoregressive distributed lags (NARDL) modeling to address non-linearity or asymmetry. In this study, in addition of testing the Romer (1993) hypothesis of a negative relationship between openness and inflation for Côte d'Ivoire, we analyze the non-linear relationship between inflation and openness using the NARDL technique. Assuming that the relationship between openness and inflation is *a priori* linear and symmetric mays be unappropriated and lead to wrong results. Only few studies (Lin, 2010; Ajaz et al.,

2016; Babatunde, 2017) proceeded like that and, to the best of our knowledge, no empirical study has been devoted to the case of Côte d'Ivoire. The NARDL technique is an extension of the Pesaran and Shin (1999) and the Pesaran et al. (2001) ARDL model through which non-linearity are incorporated by the mean of positive and negative asymmetric components. The NARDL technique is a flexible way of modelling short and long runs asymmetric in macroeconomics. The idea behind this type of modelling is that positive and negative changes in openness may not affect inflation in the same way.

In this paper, to address the problem openness measurement, we analyze the relationship between openness and inflation for Côte d'Ivoire using a recent globalization measure namely the KOF Globalization Index. This index construction is based on three dimensions of globalization: Economic, social and political (Dreher, 2006; Gygli and Sturm, 2018) and is likely to provide more reliable results than other traditional measures of openness such as the Imports plus Exports to gross domestic product (GDP) ratio (Samimi et al., 2012; Syed, 2012). The use of the KOF index for the case of Côte d'Ivoire is also an original approach in this paper.

The interests in studying the inflation-openness nexus are multiple and one of them relies on the policy implications which are consequent to the direction of the link and whether or not there exists a link between those two variables. In a context of globalization and where most Central Banks' main objective is to ensure low levels of inflation, the effectiveness of fiscal and monetary policies could be challenged due to the possible effects of openness on inflation.

The rest of this paper is structured as follows. Section 2 provides a literature review on linear and non-linear relationship of the inflation-openness nexus. Section 3 presents the empirical framework. Section 4 presents the results and Section 5 concludes.

2. LITERATURE REVIEW

Theoretically, openness can negatively affect inflation by the market competitiveness and productivity mechanisms. Binici et al. (2012) empirically validate this theory for OECD countries. Iyoha (1971) developed a theory on the effect of openness on inflation in less-developed countries. Considering two countries and by using a macrotrade model, the author found a negative effect of openness on inflation. According to Terra (1998), there is a strong negative relationship between openness and inflation in countries where there is high debt burden.

Openness (or globalization) directly affect inflation through import prices. High cost countries will see the prices of goods fall. But according to Rogoff (2006), it is the relative prices which are affected but not the absolute prices. In an indirect way, the effect of openness on inflation comes from enhancing competition that is generated by openness. This results in a disequilibrium in the demand and supply and, because there are more products available, inflation rates tend to low.

The Romer's (1993) theory on the openness-inflation nexus is based on Kydland and Prescott (1977), Barro and Gordon (1983) and Fischer (1990). In his theory, Romer (1993) advocated that the well-known trade-off about inflation and output is affected by openness. Romer (1993) consequently to his theory proposed a negative empirical effect of openness on inflation. In developed countries, openness is found to be unrelated to inflation. Moreover, openness strongly reduce inflation in countries which have instable political environment and where central banks are less independent. One of the explanation of the negative relationship between openness and inflation is based on factors such as the government budget and seignorage. Indeed, the more open is an economy, the higher is the quantity of revenue collected by governments through tariffs. Hence, revenues that traditionally come from seignorage tend to decrease; therefore, inflation rates are low. Another reason pointed out by Romer (1993) is that when an economy is opened, there is an availability of foreign currencies and economic agents can easily have substitutes for domestic currency and then the inflation rate becomes low.

Cooke (2010) reported that inflation rate can be important when the openness rate is high. According to the author, the mechanisms through which openness affects inflation are double. First, in the presence of high rates of openness, there is a steepening in the Philips curve which leads to an increase of inflation cost. Second, an improvement in the terms of trade may be followed by high inflation rate because consumption is increased due to the increase of output. In a new growth theory framework, Jin (2000) had already unraveled the role of output in explaining the negative effect of openness on inflation. The main mechanisms are: Better allocation of resources, better capacity utilization, and increased foreign investment.

Triffin and Grudel (1962) found that a high rate of openness leads to low levels of inflation. Particularly, there is a decrease in the price of expensive goods. Their study focused of five countries of European Economic Community and put forward spillover effects in explaining the negative effects of openness on inflation. Whitman (1969) also explained the negative relationship between openness and inflation by spillover mechanisms. According to the author, internal inflationary and deflationary pressures do not exert pressure on domestic prices and production. They rather spill over into the balance of payments by the mean of important marginal propensities to import.

Iyoha (1973) conducted a cross-section analysis on the relationship between openness and inflation for 33 less developed countries. The objective of their work was to check the validity of previous results found by Triffin and Grudel (1962) and Whitman (1969) for developed countries. Iyoha (1973) showed out a negative effect of openness on inflation. Openness was measured by the ratio import/income. The negative effect obtained is the result of capital accumulation that is due to the increase of openness. Sachsida et al. (2003) estimated a negative effect of openness on inflation in 152 countries from 1950 to 1992. Their measure of openness is the ratio of import to GDP. The authors argued that the relationship found does not depend on the econometric technique used and is not specific to each country.

Alfaro (2005), focusing on a sample of developed and developing countries during the period 1973-1998, showed that there is no significant impact of openness on inflation in the short run. A cross-section analysis was conducted by the author but no dynamic considerations were made.

Samimi et al. (2012), using panel data analysis for a set of developed and developing countries show that openness has a positive effect on inflation. To obtain that result, the traditional measure of openness (the sum of imports and exports divided by GDP) was used. Nevertheless the effect of openness on inflation appears to be negative when another measure of openness, namely the KOF globalization index, is used. According to the authors, the KOF globalization index is a better measure of openness in that it is constructed based on three dimensions: Economic globalization, political globalization and social globalization. In that paper, inflation dynamics are captured by the one period lag value of inflation.

The negative effect of openness on inflation has also been obtained by Syed (2012) for developed countries. The author used, in a similar way like Samimi et al. (2012), the KOF globalization index and the traditional measure of openness mentioned earlier. The KOF index sub-components (political, social and economic) were incorporated in the model. For African countries, including Côte d'Ivoire, there is a positive effect of trade openness on inflation. The explanation of this result, according to Syed (2012) is that the increase on openness rises output and employment, and by a mechanism *à la Philips,* results in an increase in inflation. A negative effect of social and political globalization on inflation is found.

Binici et al. (2012) showed that trade openness does not affect inflation in OECD countries. Munir et al. (2015) documented the impact of trade openness on inflation for height Asian countries during the period 1976-2010. Their analysis was based on panel data estimates, mainly fixed and random effects models. Their results suggested that there is no effect of trade openness on inflation, and thus, that the Romer (1993) hypothesis is not valid for the selected countries.

Yiheyis (2013) provided evidence of a positive effect of trade openness on inflation for a sample of 31 African countries including Côte d'Ivoire for the period 1980-2008. The exposition of the countries understudy to foreign price shocks seems to explain that result.

Concerning the country-specific case, Afzal et al. (2013), using ARDL model, found a negative relationship between inflation and openness in both short and long runs for Pakistan during the period 1970 to 2009. Evidence was also provided for a bidirectional causal relationship between the two variables. Zombe et al. (2017) found a bidirectional causal relationship between inflation and openness for Zambia during the period 1985-2015, using the Toda and Yamamoto causality test. Their results also showed out a positive relationship between the two variables for Zambia. They justified that result by the small size of Zambia's economy which is imports-oriented. According to Zombe et al. (2017), the more open is an economy, the more it is difficult for authorities to control inflation by the mean of monetary or fiscal policy. Zakaria (2010) documented such mechanism as well. He found, on the opposite of Afzal et al. (2013), a positive effect of openness on inflation for Pakistan from 1947 to 2007. Mukhtar (2010) also found a negative relationship between openness on inflation for the case of Pakistan. A vector error correction model and cointegration techniques were applied by the author.

In an empirical study for Nigeria, Ada et al (2014) validated the Romer's (1993) hypothesis for Nigeria, using a vector error correction model approach.

Using ARDL model, Salimifar (2015) provided empirical evidence on an inverse nexus between inflation and openness for Iran from 1973 to 2010. This result was obtained by using non-oil trade openness. The author proceeded like that because the Iran's economy is oil-dependent. According to the authors, through openness, cheaper foreign goods enter in Iran and thus, the inflation decreases. Policies aiming to reduce import tariffs, tariff barriers were suggested by the author to fight against inflation.

Researches analyzing the nonlinear relationship between inflation and openness are not as numerous as those dealing with the linear relationship, particularly in the context of African countries. Some examples can be found though.

Quantile regression was used by Lin (2010) to analyze the link between trade openness and inflation from 1970 to 2007 for a panel of 106 countries. The author found that when inflation is low, trade openness does not affect inflation. However, for higher values of inflation, trade openness has a negative effect on inflation.

Syed and Zwick (2015) provided a theoretical analysis of the relationship between trade openness and inflation in a non-linear convex Philips curve framework. The increase of the openness leads to an increase in economic activity which in turn have a negative effect on unemployment and thus on inflation. This is particularly true for countries having a high potential of exports. Import price channel is also a theoretical channel through which openness affects inflation in a negative way. Indeed, imports of low cost goods play a significant role in reducing inflation in countries with high level of prices.

Through an asymmetric modelling, Ajaz et al. (2016) analyzed the link between openness and inflation in India during the period 1970-2014. Their paper also aimed to test the Romer (1993) hypothesis for the case of India. The NARDL model developed by Shin et al. (2014) was used for that purpose. Ajaz et al. (2016) tested for the long and short runs asymmetries between the negative and the positive components of each variable of their model. They found the absence of a long run asymmetry between the negative and the positive components of openness and the presence of a short run asymmetry between the components. They also showed out a small positive but non-significant effect of the long run positive component of openness on inflation. Another result of the paper is a positive and significant effect of the long run negative component on inflation. The authors, justifying these

results, mentioned the nature of the openness variable used, the sum of imports and exports divided by GDP. According to them, this proxy measures openness ex-post and is probably not a good measure of the ex-ante openness. The structure of India's trade also seems to be an explanation of the positive effect previously mentioned. Indeed, India's trade is mainly dominated by oil and manufactured goods which tends to exert an upward pressure on inflation. A dynamic multiplier analysis conducted by Ajaz et al. (2016) showed that there is a gap between the impact of the positive and the negatives changes in openness on inflation, and this gap is growing over the time. This last result also support the presence of an asymmetric link between inflation and openness in India. Globally, the Romer (1993) hypothesis does not hold for India.

The Nigeria's case has been studied by Babatunde (2017), basing on a NARDL framework where both short and long runs nonlinearities between inflation and trade openness were analyzed for the period 1980-2015. The results showed a positive and significant effect of the long run asymmetric components of openness on inflation. However, the magnitude of the negative component is slightly superior to the magnitude of the positive component. In short run, the asymmetric effects of openness on inflation depend on the temporal horizon. Indeed, both positive and negative effects were found. Nigeria's economy depends on imports so that when crude oil's price encounters a decrease, instead of lower, the level of imports increases due to the depreciation of exchange rate in the short run. Consequently, this depreciation cause in the long run a rise in production costs and thus an inflationary pressure in the economy.

Regarding Africa, empirical studies, whether they are conducted using panel data analysis or are country-specific, found a positive effect of openness on inflation, from a linear point of view. Syed (2012) and Yiheyis (2013) conducted panel data analysis and included Côte d'Ivoire in their sample. Except Babatunde (2017) for the case of Nigeria and Ajaz et al. (2016) for the case of India, no studies used a NARDL approach to analyze the linkage between inflation and openness.

3. EMPIRICAL FRAMEWORK

3.1. Data and sources

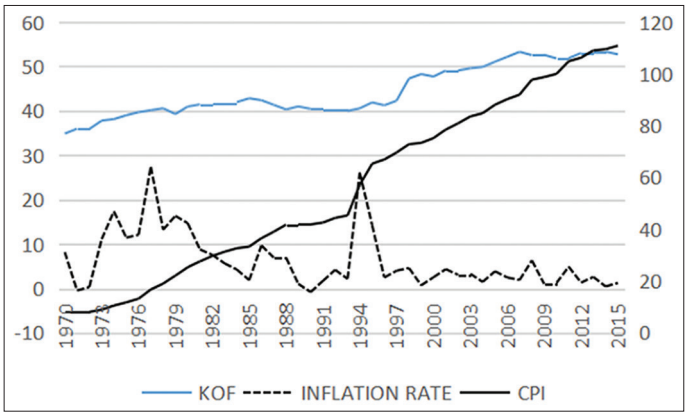
In this study, the objective is to analyze the relationship between openness and inflation in Côte d'Ivoire using a non-linear asymmetric framework. We use annual data from 1970 to 2015. The time-period is chosen for the reason that the data on inflation are available from 1970 to 2015. Inflation is measured by the Consumer Price Index and is taken from the IMF World Economic Outlook database. The use of Consumer Price Index is largely found in the inflation-openness empirical literature. The KOF globalization index, a larger measure of globalization, developed by the KOF Swiss Economic Institute is used as a measure of openness. This choice is made because the KOF globalization index is a better proxy for openness (Samimi et al., 2012; Syed, 2012). These authors argued that the results obtained by using the KOF index provide a broader view of the relationship between openness and inflation, view that is not possible to find with traditional measures of openness. Indeed, the KOF index, in its construction, is based on three dimensions of globalization: Economic, social and political (Dreher, 2006; Gygli and Sturm, 2018). The sub-components of economic globalization are: Trade and financial globalization. The social globalization sub-components are: Interpersonal, information and cultural globalization. Political globalization is related to the extent to which domestic government is receptive to foreign governmental influence and resources. An example is the presence of embassies. The KOF index takes its value between 1 and 100, with highest value corresponding to a high level of globalization. Few studies used the KOF index to analyze the link between openness and inflation (Samimi et al., 2012; Syed, 2012; Chang and Tsai, 2014) and, to the best of our knowledge, the index has not been for the specific case of Côte d'Ivoire. Other variables, which play the role of control variables are also used in the empirical framework. Those variables were selected basing on the inflation-openness related empirical literature. Those variables are: General government final consumption expenditure (% of GDP), Exchange rate and GDP per capita. GDP per capita is used to control for the level of economic development. All the control variables are taken from the World Development Indicators database. All the variables are taken in the natural logarithm.

We give a particular attention to the Consumer Price Index and the KOF globalization index. Figure 1 shows the evolution of the two variables from 1970 to 2015. Globally, both variables have known an increase from 1970 to 2015 and have both positive and negative variations. Until 1995, the inflation rate was high in Côte d'Ivoire. After that year and until 2015, the inflation rate has been relatively low. One remark is that the decrease observed in the inflation rate corresponds to an increase in the KOF index. From 1970 to 1995, when the KOF index was at its low levels, the inflation rate was high. A relation *à la Romer* between inflation and openness seems to appear from 1995 to 2015. This relation will be tested in the empirical framework. The KOF globalization index's variations are more accented than the ones of Consumer Price Index. Indeed, the former presents more positive and negative variations than the latter. This finding intuitively supports the decomposition of the KOF index into positive and negative variations in the empirical framework. From Figure 2, what can be noticed is that the Political Globalization is more important than the economic globalization and the social globalization. Furthermore, there is an overall upward trend for all the three indexes.

3.2. The Unit Root Test

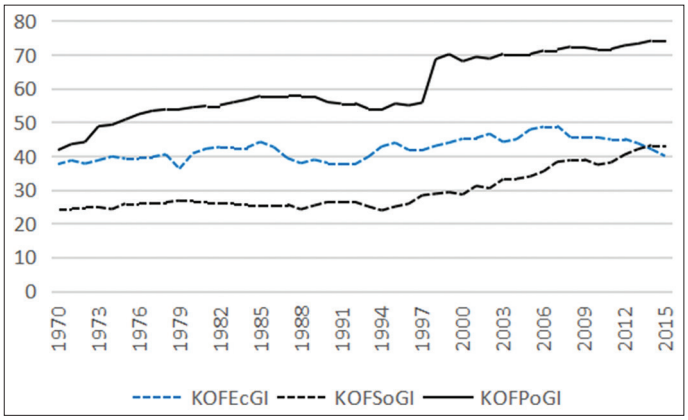
The determination of the order of integration of the variables is necessary before estimated an ARDL model. The reason is that to estimate the model, none of the variables must be integrated of order two. Moreover, the dependent variable should be integrated of order one. That said the NARDL model can be used whether the variables are I(0) or I(1), but not I(2). In order to be coherent with the non-linear aspect of the NARDL model, the stochastic properties of the data are tested using unit root test that take into account non-linearity, specifically structural break. This is justified by the fact that using a unit root test when there is structural break in the data may lead to biased conclusions regarding the stochastic properties of the data. In this study, the Zivot and Andrews (1992) unit root test is conducted. The null hypothesis of the test is the presence of unit

Figure 1: Evolution of the CPI, the inflation rate and the KOF index in Côte d'Ivoire from 1970 to 2015



Source: WDI, KOF Swiss Economic Institute and author's calculation

Figure 2: Sub-components of KOF globalization index for Côte d'Ivoire from 1970 to 2015



Source: KOF Swiss Economic Institute and author's calculation.
Note: KOFEcGI - Economic Globalization index; KOFSoGI - Social Globalization index; KOFPoGi - Political Globalization index

root with structural break. When the Zivot-Andrews t-statistic is >5% critical value, then there is enough statistical evidence against the null hypothesis. On the contrary, when the Zivot-Andrews t-statistic is <5% critical value, the variable is stationary. As a robustness check for the Zivot-Andrews unit root test, we computed minimum Dickey-Fuller t-statistics following Perron and Vogelsang (1992) and Vogelsang and Perron (1998). Their unit root test also accounts for structural breaks and, similarly to the Zivot-Andrews test considers as unknown the date of the break.

3.3. The Nonlinear ARDL Model

The choice of a non-linear model finds one of its justification in the concept of hidden cointegration of Granger and Yoon (2002). The hidden cointegration is obtained when the positive and negative components of the series are cointegrated. Another reason of the use of a non-linear specification is related to the presence of structural break.

Numerous empirical studies have used the NARDL developed by Shin et al. (2014) to address the asymmetric relations between macroeconomic variables. The method focuses on detecting short and long runs asymmetries in a non-linear framework. The NARDL also combines a non-linear long run relationship with a non-linear error correction. The first step of the implementation of the NARDL model is to decompose the variable of interest into positive and negative partial sums.

$$KOF_t = KOF_0 + KOF_t^+ + KOF_t^- \quad (1)$$

In equation (1), the effect of an increase in openness on inflation is captured by $KOF^+$and the effect of a decrease in openness is captured by KOF^-.

$$KOF_t^+ = \sum_{i=1}^{t} \Delta KOF_i^+ = \sum_{i=1}^{t} \max(\Delta KOF_i, 0) \quad (2)$$

$$KOF_t^- = \sum_{i=1}^{t} \Delta KOF_i^- = \sum_{i=1}^{t} \min(\Delta KOF_i, 0) \quad (3)$$

In equations (2) and (3), $\Delta KOF_t = \Delta KOF_t - \Delta KOF_{t-1}$

The asymmetric error correction representation is:

$$\Delta CPI_t = \begin{array}{l} \alpha + \rho_1 CPI_{t-1} + \rho_2^+ KOF_{t-1}^+ + \\ \rho_2^- KOF_{t-1}^- + \rho_3 X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta CPI_{t-i} + \\ \sum_{i=0}^{q} (\beta_i^+ \Delta KOF_{t-i}^+ + \beta_i^- \Delta KOF_{t-i}^-) + \sum_{i=0}^{r} \delta_i \Delta X_{t-i} + \varepsilon_t \end{array} \quad (4)$$

Where CPI is the consumer price index, KOF represents the openness measured by the KOF globalization index, X is a vector containing the control variables. The letters *p, q, r* represent the lag orders for the variables. ε_t is the disturbance term.

The coefficients ρ_2^+ and ρ_2^- allow to capture the long run asymmetry while β^+ and β^- captured the short run asymmetry. The presence of cointegration relationship is tested by the mean of the following null hypothesis: $H_o : \rho_1 = \rho_2^+ = \rho_2^- = \rho_3 = 0$ (Pesaran et al., 2001; Shin et al., 2014). The computed statistic of the bound test is compared to the critical value tabulated by Narayan (2005). This is because our study uses a sample of 46 observations and according to Narayan and Smith (2005), the Pesaran et al. (2001) critical values for the bounds testing approach to cointegration are not suitable for small size samples. To deal with that issue, Narayan (2005) computed critical values for samples containing 30 to 80 observations. If the F-statistic is higher than the upper bound of the critical values, then the null hypothesis of no cointegration is rejected and there is evidence of the presence of cointegration among the series. A Wald test is used to test the long run symmetry. The test is based on the null: $-\rho_2^+ / \rho_1 = -\rho_2^- / \rho_1$. The long run equilibrium relationship between openness and inflation is measured through the coefficients: $L^+ = -\rho_2^+ / \rho_1$ and $L^- = -\rho_2^- / \rho_1$.For the short run symmetry, the null hypothesis is: $\beta_i^+ = \beta_i^-$, for all *i=0,...,q*. When the null hypothesis are rejected, then the model is asymmetric for the corresponding time-horizon. Say differently, there may be a short run asymmetry, a long run asymmetry or both short and long runs asymmetries.

The asymmetric effect of openness on inflation in Côte d'Ivoire is also analyzed through the use of openness quantiles (Pal and Mitra, 2015 for a similar approach). Lin (2010) also analyzed the relationship between openness and inflation using quantile regression. This choice is motivated by the fact that the effect of small values of openness on inflation may differ from the effect of large values. Thus, we decompose the KOF globalization index into three partial sum series using openness 75th, 50th and 25th quantiles which are denoted by τ_{75},τ_{50} and τ_{25}

$$KOF_t = KOF_0 + KOF_t(\omega 1) + KOF_t(\omega 2) + KOF_t(\omega 3) \quad (5)$$

Where

$$KOF_t(\omega 1) = \sum_{i=1}^{t} \Delta KOF_i(\omega 1) = \sum_{i=1}^{t} \Delta KOF_i I\{\Delta KOF_i > \tau_{75}\}$$

$$KOF_t(\omega 2) = \sum_{i=1}^{t} \Delta KOF_i(\omega 2) = \sum_{i=1}^{t} \Delta KOF_i I\{\tau_{25} < \Delta KOF_i \le \tau_{75}\}$$

$$KOF_t(\omega 3) = \sum_{i=1}^{t} \Delta KOF_i(\omega 3) = \sum_{i=1}^{t} \Delta KOF_i I\{\Delta KOF_i \le \tau_{25}\}$$

I{.} is an indicator function. A similar NARDL representation as in Equation (4) can also be written is this case.

$$\begin{aligned} \Delta CPI_t = {} & \alpha + \rho_1 CPI_{t-1} + \rho_2 KOF_{t-1}(\omega 1) + \\ & \rho_3 KOF_{t-1}(\omega 2) + \rho_4 KOF_{t-1}(\omega 3) + \\ & \rho_5 X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta CPI_{t-i} + \sum_{i=0}^{q} (\beta_{1i} \Delta KOF_{t-i}(\omega 1) + \\ & \beta_{2i} \Delta KOF_{t-i}(\omega 2) + \beta_{3i} \Delta KOF_{t-i}(\omega 3)) + \\ & \sum_{i=0}^{r} \delta_i \Delta X_{t-i} + \varepsilon_t \end{aligned} \quad (6)$$

The coefficients ρ_2, ρ_3 and ρ_4, capture the long run asymmetry while β_{1i}, β_{2i} and β_{3i} capture the short run asymmetry. The presence of cointegration relationship is tested by the mean of the following null hypothesis: H_o: $\rho_1=\rho_2=\rho_3=\rho_4=\rho_5=0$. The long run symmetry test is based on the null: $-\rho_2/\rho_1 = -\rho_3/\rho_1 = -\rho_4/\rho_1$. The long run equilibrium relationship between openness and inflation is measured through the coefficients: $L_{\omega 1}=-\rho_2/\rho_1$;$L_{\omega 2}=-\rho_3/\rho_1$ and $L_{\omega 3}=-\rho_4/\rho_1$. For the short run symmetry, the null hypothesis is: β_{1i}, β_{2i} and β_{3i} for all $i=0,\ldots,q$.

4. RESULTS

4.1. The Unit Root Test Results

The results of the Zivot-Andrews unit root test are presented in Table 1. The Consumer Price Index is not stationary at level and is rather integrated of order one. The presence of unit root in the others series depends on the specification chosen for the test. Nevertheless, none of the variables are integrated of order 2. From Table 2, which presents the results of the unit root test following Perron and Vogelsang (1992) and Vogelsang and Perron (1998), all the variables are stationary at level, except the Consumer Price Index, the Exchange rate and the GDP per capita which are stationary at first differences. These results satisfy one necessary condition for the implementation of the NARDL model. As a reminder, the dependent variable must be integrated of order one and none of the variables must not be integrated of order two.

Coming back to some break dates provided by the Zivot-Andrews test, the break occurred in 1994 in the evolution of the exchange rate series may be due to the FCFA devaluation which occurred in 1994. The FCFA devaluation changed the Euro-FCFA parity and thus the Dollar US-FCFA parity, causing a structural break.

Starting from the 80s, a decrease in Cote d'Ivoire's GDP per capita is observed and this could explained the 1983 break computed by the Zivot-Andrews test. Indeed, the evolution of Cote d'Ivoire's GDP per capita started with the value of 1887 US Dollars in 1970 and stand at 2392 US Dollars in 1978. Starting from 1979, the GDP per capita decreased and the value of 1470 US Dollars has been observed in 2015.

From 2002 to 2007, period which corresponds to the Ivoirian politico-military crisis, GDP per capita dropped from 1264 US Dollars to 1207 US Dollars respectively. After 2007, an uptrend has been recorded and this seems to explain the breaks in 2006 and 2007.

The 1994 break observed for the government expenditure could be related to the effects of structural adjustment programs.

Concerning the KOF globalization index, a significant increase is observed in 1998 and this could validly explained the break of 1998 identified by the structural break test. Finally, rapid increase is observed in the evolution of Consumer Price index starting from 1999 and there seems to rely the reason why there is a break in the intercept of that series in 1999.

4.2. The NARDL Estimation Results

The adequate NARDL specification is chosen by using a general-to-specific approach starting with $p=p=r=3$, and by dropping all the insignificant lags. A similar approach was used by Katrakilidis and Trachanas (2012), Shin et al. (2014) and Ibrahim (2015). We set the maximum lags to three because of the relative small size of our sample (Tables 3 and 4). The validity of the NARDL model is assessed through cointegration and asymmetric testing. The adequacy of the NARDL is also verified by using some diagnostic tests of normality, serial correlation, heteroscedasticity and stability. Stability is tested using the cumulative sum and cumulative sum of squares tests of recursive residuals developed by Browns et al. (1975).

Results from Figures 3 and 4 indicate that there is no instability in the models we have estimated. Indeed, the CUSUM and CUSUM squares statistics do not cross the 5% critical bounds. Concerning the diagnostic tests, the error terms are normally distributed, are not auto correlated and are homoscedastic. The R^2 and adjusted R^2 suggest that the explanatory variables variations explain a high portion of inflation in Côte d'Ivoire. The models from Tables 1 and 2 exhibit asymmetry in short and long runs. We can see that from the Wald tests statistics for short and long run symmetries are statistically significant. This means that there is a short and long runs asymmetry in the relationship between openness and

Table 1: The Zivot-Andrews unit root test result

Variables	Model A: Break in intercept				Model B: Break in Trend				Model C: Break in both trend and intercept			
	Break	Lag	Min. t-stat	5% critical value	Break	Lag	Min. t-stat	5% critical value	Break	Lag	Min. t-stat	5% critical value
CPI	1999	1	−1,999	−4,93	-	-	-	-	-	-	-	-
KOF	1998	0	−4,969	−4,93	1991	0	−2,486	−4,42	1998	0	−4,489	−5,08
KOF+	1987	0	−5,691	−4,93	1994	0	−3,193	−4,42	1987	0	−5,635	−5,08
KOF−	1998	0	−6,302	−4,93	1989	0	−1,975	−4,42	1998	0	−5,737	−5,08
KOF (w1)	1994	0	−7,452	−4,93	1998	0	−6,527	−4,42	1994	0	−7,527	−5,08
KOF (w2)	1993	0	−7,036	−4,93	2005	0	−5,988	−4,42	1996	0	−7,136	−5,08
KOF (w3)	1990	0	−6,543	−4,93	1979	0	−6,281	−4,42	1990	0	−6,751	−5,08
EXCHANGERATE	1994	0	−3,654	−4,93	2001	0	−2,846	−4,42	1994	0	−4,365	−5,08
GDPPERCAPITA	1983	1	−2,201	−4,93	2007	1	−2,4503	−4,42	2006	1	−2,4202	−5,08
GOVEXPEND	1994	1	−5,209	−4,93	1980	1	−4,069	−4,42	1994	1	−5,167	−5,08

CPI: Consumer price index; KOF: KOF Globalization index; EXCHANGERATE: Official exchange rate (Local Currency Unit per US$, period average); GDPPERCAPITA: GDP per capita; GOVEXPEND: Government expenditure (% GDP)

Table 2: Unit root test with structural break (Perron and Vogelsang, 1992; Vogelsang and Perron, 1998)

Variables	Level	First difference
CPI	−4,045	−5,471***
KOF	−4,704*	-
KOF+	−6,104***	-
KOF−	−5,546***	-
KOF (w1)	−10,666***	-
KOF (w2)	−8,499***	-
KOF (w3)	−6,859***	
EXCHANGERATE	−3,554	−7,692***
GDPPERCAPITA	−2,045	−5,331***
GOVEXPEND	−5,010**	-

CPI=Consumer Price index; KOF=KOF Globalization index; EXCHANGERATE: Official exchange rate (Local Currency Unit per US$, period average); GDPPERCAPITA: GDP per capita; GOVEXPEND: Government expenditure (% GDP)

inflation in Côte d'Ivoire. If a simple linear ARDL model were considered in this study, then the results obtained would have been biased. As shown by the bounds test, there is also a cointegration relationship between the variables. In both cases (Tables 1 and 2), the computed value for the test is >4.268 value taken from Narayan (2005) at the 5% level.

Once the NARDL specification and diagnostic tests are all valid, we can now proceed to the interpretation of the results. We first focus on the long run asymmetry effect of openness on inflation. In Table 1, the coefficients L^+ and L^- are respectively 1.013 and −7.845 and represent the asymmetric long runs effects of openness on inflation. Both coefficients are statistically significant. The analytical interpretation for the L^+ coefficient is that a 1% increase in openness leads to a 1.013% increase in Cote d'Ivoire's inflation. This result is in accordance with panel data studies on Africa which showed a positive effect of openness on inflation (Syed, 2012; Yiheyis, 2013). From a policy view, this means that the Central Bank's inflation reducing policy will still hold and have effects in Côte d'Ivoire, since a negative effect of openness on inflation is not found. For the L^- coefficient, a 1% decrease in openness leads to a 7.845% decrease in Côte d'Ivoire's Consumer Price Index. As we can see, the effect of a decrease in openness is more important than the effect of an increase in openness. This means that inflation reacts more strongly to a decrease in openness than to an increase in openness.

Now we turn to the short run asymmetric analysis. First regarding the short run KOF^+ coefficient, the one and three period lagged value appears to significantly affect inflation. The one period lagged value has a positive impact (0.887) on inflation and the three period lagged value has a negative (−1.249) impact on inflation. From these results we could argued that the incentive of the Central Bank to generate surprise inflation may lower over the time. The results suggest that the Central Bank should give particular attention to openness movements, as the effect on inflation is time-specific. More precisely, the Central Bank's policies could be adjusted given the openness movements.

Contrary to the KOF^+ coefficient, the contemporaneous value of KOF^- negatively (−3.336) affects inflation in the short run. But similarly to KOF^+, the three period value of KOF^- also affect inflation but the effect is positive and the coefficient is equal to 1.611. These results comfort us in the fact that in the short run, the asymmetric effect of openness on inflation depends on the temporal horizon.

To further analyze the presence of asymmetry in the inflation-openness nexus, we use quantile decomposition of openness. As a reminder, the KOF globalization index is decomposed into three partial sum series using openness 75^{th}, 50^{th} and 25^{th} quantiles. The long run estimates show a positive but non-significant effect of KOF (ω1) on inflation, a positive and significant effect of KOF (ω3) on inflation and a negative significant effect of KOF (ω2) on inflation. The interpretation of these results is that when openness is low, an increase of openness lead to an increase of inflation. This result could be explained by the fact that rapid increase in openness is observed when openness is low. Thus, the impact on inflation is important.

In the short run, the effects of the partial quantiles decomposition of openness on inflation are more mixed. The one period lagged value of KOF (ω1) has a positive effect on inflation. This effect could be explained by the fact that when openness is high, an additional increase generates inflationary pressures on the Ivoirian's economy. The contemporaneous value of KOF (ω2) has a negative effect on inflation while the two and three periods lagged value positively affect inflation. Moreover, inflation is positively and significantly affect by the contemporaneous value

Table 3: Results of the NARDL estimates using positive and negative partial sums of openness

Variables	Coefficient	Std. Error
CPI_{t-1}	−0.238***	0.063
KOF^{+}_{t-1}	0.241*	0.132
KOF^{-}_{t-1}	−1.867***	0.622
$EXCHANGERATE_{t-1}$	0.184***	0.051
$GDPPERCAPITA_{t-1}$	0.294**	0.137
$GOVEXPEND_{t-1}$	0.268**	0.126
ΔEXCHANGERATE	0.259***	0.056
$\Delta EXCHANGERATE_{t-2}$	−0.149***	0.059
ΔCPI_{t-2}	−0.357**	0.173
ΔKOF^{+}_{t-1}	0.887**	0.432
$\Delta GOVEXPEND_{t-2}$	−0.432***	0.118
$\Delta GOVEXPEND_{t-3}$	−0.394***	0.098
ΔKOF^{-}_{t}	−3.336***	1.172
$\Delta EXCHANGERATE_{-3}$	−0.158***	0.056
ΔCPI_{t-3}	0.385*	0.215
ΔKOF^{+}_{t-3}	−1.249***	0.403
ΔKOF^{-}_{t-3}	1.611*	0.919
$\Delta GOVEXPEND_{t-1}$	−0.379***	0.109
Constant	−3.267***	1.306
R2	0.807	
Adjusted R2	0.656	
F-statistic	5.336***	
Bound test for cointegration	7.197***	
Long run asymmetry Wald test (W_{LR})	21.906***	
Short run asymmetry Wald test (W_{SR})	5.245***	
L^{+}	1.013	
L^{-}	−7.845	
Breusch-Godfrey autocorrelation LM test	2.907 (0.234)	
Breusch-Pagan-Godfrey heteroscedasticity test	19.144 (0.383)	
Jarque-Bera Normality test	0.714 (0.699)	

Dependent variable is inflation measured by Consumer Price Index. $L^{+}$and L^{-} are the long-run equilibrium coefficients of the positive and negative changes of openness, respectively. Values in brackets are pvalues. Lower and upper critical values for cointegration bound test are 2.922 and 4.268. The F-statistic is used to test the global significance for the model. CPI=Consumer Price index; KOF=KOF Globalization index; EXCHANGERATE=Official exchange rate (Local Currency Unit per US$, period average); GDPPERCAPITA=GDP per capita; GOVEXPEND=Government expenditure (% GDP). The superscripts "+" and "–" respectively denote positive and negative partial sums of openness

Table 4: Results of the NARDL estimates using quantile decomposition of openness

Variables	Coefficient	Std. Error
CPI_{t-1}	−0.090***	0.028
$KOF\ (\omega1)_{t-1}$	0.008	0.028
$KOF\ (\omega2)_{t-1}$	−0.090***	0.033
$KOF\ (\omega3)_{t-1}$	0.120***	0.047
$EXCHANGERATE_{t-1}$	0.201***	0.045
$GDPPERCAPITA_{t-1}$	0.153**	0.067
$GOVEXPEND_{t-1}$	0.059	0.101
ΔEXCHANGERATE	0.363***	0.062
$\Delta EXCHANGERATE_{t-2}$	−0.313***	0.058
$\Delta GOVEXPEND_{t-3}$	−0.213**	0.092
$KOF\ (\omega2)_{t-2}$	0.053***	0.011
$\Delta GOVEXPEND_{t-1}$	−0.194**	0.092
$KOF\ (\omega2)_{t}$	−0.045***	0.011
$\Delta GOVEXPEND_{t-2}$	−0.432***	0.118
$KOF\ (\omega3)_{t-2}$	−0.068***	0.019
$KOF\ (\omega1)_{t-1}$	0.034***	0.012
$KOF\ (\omega2)_{t-3}$	0.026***	0.006
$KOF\ (\omega3)_{t}$	0.081***	0.025
$\Delta GDPPERCAPITA_{t-2}$	0.887***	0.232
C	−2.013***	0.761
R2	0.864	
Adjusted R2	0.741	
F-statistic	7.035***	
Bound test for cointegration	11.417***	
Long run asymmetry Wald test (W_{LR})	3.953**	
Short run asymmetry Wald test (W_{SR})	6.539***	
$L_{\omega1}$	0.094	
$L_{\omega2}$	−1.005	
$L_{\omega3}$	1.337	
Breusch-Godfrey autocorrelation LM test (pvalue)	0.727 (0.695)	
Breusch-Pagan-Godfrey heteroscedasticity test (pvalue)	15.841 (0.668)	
Jarque-Bera Normality test (P value)	2.23 (0.328)	

Dependent variable is inflation measured by Consumer Price Index. $L_{\omega1}$, $L_{\omega2}$ and $L_{\omega3}$ are the long-run equilibrium coefficients of the quantile decomposition of openness. Values in brackets are pvalues. Lower and upper critical values for cointegration bound test are 2.922 and 4.268. The F-statistic is used to test the global significance for the model. CPI=Consumer Price index; KOF=KOF Globalization index; EXCHANGERATE=Official exchange rate (Local Currency Unit per US$, period average); GDPPERCAPITA=GDP per capita; GOVEXPEND=Government expenditure (% GDP)

of KOF (ω3) and negatively by the two periods lagged value. The overall results of the quantile decomposition analysis show that the relationship between openness and inflation is quantile-dependent.

After analyzing the short and long runs asymmetric effects of openness on inflation, we now proceed to the interpretation of the control variables.

In the first set of estimates, all the control variables (Exchange rate, GDP per capita, government expenditure) have a positive and significant long run effect of inflation and the results are in adequacy with the theory and some empirical facts. These results are robust to the second set of estimates, except the effect of government expenditure which still positive but non-significant. The coefficient of the lagged value of inflation is negative and strongly significant. This could mean that there is no inflation inertia or expectation in the inflationary process in Côte d'Ivoire in the long run. Analytically, this means that the disequilibrium in inflation from the previous year's shock is eliminated in the current year. The result holds in the two model specifications.

In the short run (Table 1), exchange rate positively impacts on inflation in the first period and have a negative impact on inflation in the second and third periods.

In the third period, we estimate a positive and significant effect of inflation on the current level of inflation. This means that contrary to the long run effect and to the short run two period lagged parameter, there is an inertia in inflation. We also report a negative effect of government expenditure on inflation in the short run.

The results from Table 2 confirm the short run effect of exchange rate on inflation found in Table 1. GDP per capita appears to have a positive and significant influence on inflation. The government expenditure negatively impacts on inflation as well.

The positive and negative effects of government expenditure on inflation in short run and long run respectively could be explained by the presence of a size effect mechanism. Say differently,

Figure 3: CUSUM and CUSUM Square test for the NARDL model estimated using positive

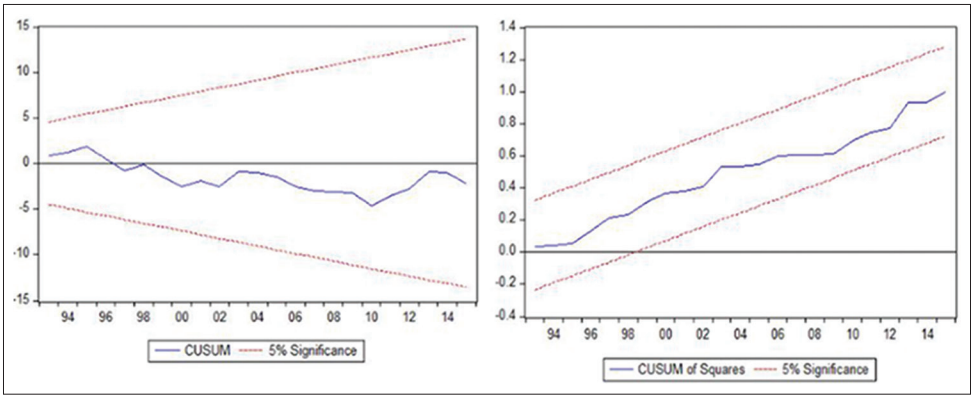
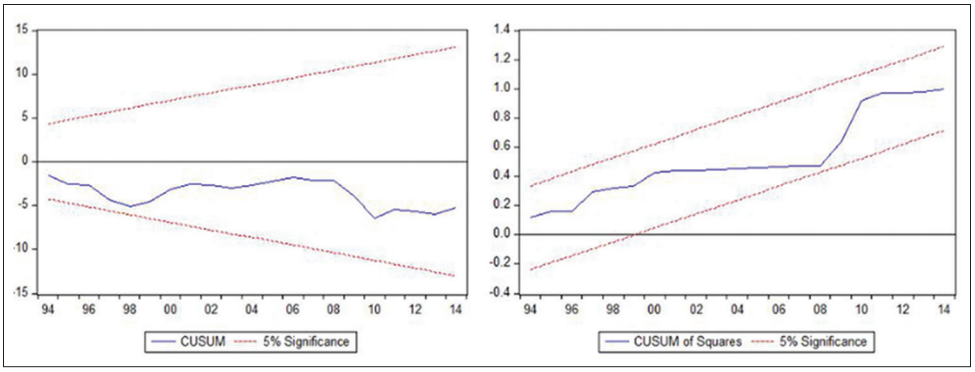


Figure 4: CUSUM and CUSUM Square test for the NARDL model estimated using quantile decomposition of openness



the more time runs, the more the government intervenes in the economy and inflationary pressures could be generated through the increase of the aggregate demand.

The overall results of the impact of the control variables on inflation support the view that the socio-economic environment play an important role in explaining inflation in Cote d'Ivoire. This suggests that policy makers in Côte d'Ivoire could base their inflation policy on the other macroeconomic variables used in this study: GDP per capita, exchange rate and government expenditure.

5. CONCLUSION

The objective of this paper is to conduct an asymmetric analysis of the relationship between openness and inflation for Côte d'Ivoire during the period 1970-2015. The empirical framework consisted in first testing the unit root properties of the variables of the study. The unit root test used (Zivot and Andrews, 1992; Perron and Vogelsang, 1992; Vogelsang and Perron, 1998) account for structural breaks and thus nonlinearities. Then, the NARDL model introduced by Shin et al. (2014) is used to test the presence of asymmetries in the openness-inflation nexus and to estimate the short and long runs asymmetric effects.

Openness is measured with the KOF Globalization Index and inflation's proxy is the Consumer Price Index. Two techniques were used to assess the presence of asymmetry. First the KOF Globalization Index has been decomposed in partial negative and positive sums. Second, partial quantiles sums are also used.

The study provides evidence of the existence of a non-linear asymmetric cointegration between openness and inflation in Cote d'Ivoire. Both short and long runs nonlinearities were found in the inflation-openness nexus. In the long run, an increase of 1% in openness leads to an increase of 1.013% in inflation. This means that the Romer's (1993) hypothesis is not valid for Côte d'Ivoire in the long run. Inflation responds more to a decrease in openness. Indeed, a 1% decrease in openness leads to a 7.845% decrease in inflation. In short run, positive changes in openness and inflation are positively correlated in the first period and negatively correlated in the third period. Negative changes in openness are negatively correlated to inflation in the current period and positively related to inflation in the third period. The quantile decomposition analysis further confirms the asymmetric nature of the relationship between openness and inflation. In long run and for low values of openness, the effect of openness on inflation is positive. A possible explanation of this finding is that rapid increase in openness is observed when openness is low and consequently, the impact on inflation is more important. Moreover, for its high values, openness also positively affects inflation but the impact is not significant. Apart from these results, we find that for median values of openness, the effect on inflation is negative. Our results emphasize on the necessity of policy makers to take into account the movements of openness in their inflation-reducing policies.

Since the KOF Globalization index used in this study is constructed based on three dimensions, future researches could analyze the disaggregated effects of each components of the KOF Globalization Index on Côte d'Ivoire's inflation. This will allow to further assess the differential effects of economic, social and political globalization on inflation.

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