The Exchange Rate Pass-Through to Inflation and its Implications for Monetary Policy in Cameroon and Kenya

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The Exchange Rate Pass-Through to Inflation and its Implications for Monetary Policy in Cameroon and Kenya

By

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Abstract

Understanding how domestic prices adjust to the exchange rate enables us to anticipate the effects on inflation and monetary policy responses. This study examines the extent of the exchange rate pass-through to the Consumer Price Index in Cameroon and Kenya over the 1991-2013 period. The results of its econometric analysis shows that the degree of the exchange rate pass-through is incomplete and varied between 0.18 and 0.58 over one year in Kenya, while it varied between 0.53 and 0.89 over the same period in Cameroon. For the long term, it was found to be equal to 1.06 in Kenya and to 0.28 in Cameroon. A structural VAR analysis using impulse-response functions supported the results for the short term but found a lower degree of pass-through for the exchange rate shocks: 0.3125 for Kenya and 0.4510 for Cameroon. It follows from these results that the exchange rate movements remain a potentially important source of inflation in the two countries. Variance decomposition shows that the contribution of the exchange rate shocks is modest in the case of Kenya but significant in that of Cameroon.

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1. Introduction

The rise in global economic integration has been accompanied by the idea that macroeconomic variables in a given country (such as measures of economic activity, inflation, and interest rates) are expected to increasingly be affected by the events happening in the rest of the world (Guilloux and Kharroubi, 2007; IMF, 2006). Indeed, the intensification of international economic and financial integration (globalization) should mean that the economic and financial disruptions that occur in one economy are more likely to be transmitted to another economy than was the case before. This helps to understand why globalization has become a primary concern for both academics and policy makers. Indeed, there has been an intensification of debate, research programmes and political agendas to understand the different influences of globalization on national economies and their management.

Economic theory suggests that the key elements of a monetary policy framework, such as inflation, and how its effects are transmitted may be affected by the global integration of financial and goods markets through different channels (Kaneez, 2013). Globalization affects the structure and functioning of the financial and economic environment in which monetary policy operates. Thus, the conduct of monetary policy is also influenced, given that the relative importance of the channels through which monetary policy is transmitted can vary. In an integrated economic environment, shocks can be easily and quickly transmitted across borders as long as the links between the real variables have implications for the nominal ones. That is why it is important to understand the implications of globalization for monetary policy.

One of the many influences that globalization can have on monetary policy is imported inflation.[1] This can be defined as an increase in the general level of domestic prices due to an increase in the prices of imported goods and services. Imported inflation can be caused by fluctuations in the exchange rate or by those in the prices of imported products measured in foreign currency (Mihaljek and Klau, 2001).

Against this background, and regarding Sub-Saharan African economies which are small economies that are increasingly open and heavily dependent on imports (Fatai and Akinbobola, 2015), which is the case of the economies of Cameroon and Kenya, it would be reasonable to assume that the impact of imported inflation on domestic inflation is very high. This could make monetary policy (using the standard monetary policy tools) less effective in controlling inflation. This is all the more relevant for those African countries that have adopted market-determined exchange rate regimes and

have gradually opened a capital account (Aron et al, 2014a).[2] Therefore, determining the implications of imported inflation for the trends in domestic prices, and the ability of the monetary policies put in place to control them, is a challenging issue for the monetary authorities across the world and in sub-Saharan Africa. After all, price stability is one of the ultimate goals of monetary policy.

Studies on imported inflation have generally focused on the effect of the exchange rate movements on domestic prices,[3] which has been called exchange rate pass-through (ERPT)[4] (Aron et al, 2014b). The exchange rate movements have been identified as one of the determinants of a country's competitiveness on the global market (Goldberg and Hellerstein, 2008). In addition, in a small economy, the exchange rate provides an important channel for monetary policy transmission since exchange rate movements can affect the domestic inflation rate. Therefore, enhancing understanding of this effect on the economy is a good starting point in the formulation of both the trade policy and the monetary policy.[5]

Research on this subject and on Sub-Saharan African countries has been limited. Most studies on the subject are about developed countries, while a good number of them are about emerging markets. The few (and most cited) studies on Sub-Saharan Africa are: Choudhri and Hakura (2006), Barhoumi (2006), Bhundia (2002), Kiptui et al (2005), Akofio-Sowah (2009), and Razafimahefa (2012). The author is aware of Kiptui et al (2005) study as the only one dealing exclusively with Kenya and is not aware of any dealing with Cameroon. One particular result emerges from all these studies: the degree to which the exchange rate movements are transmitted to prices is incomplete and lagged.

However, the estimations reported in those studies were done using models that did not consider important control variables, namely domestic and foreign costs, and domestic and foreign demand (Aron et al, 2014b), with the effect of producing biased and inconsistent estimations. The simplest single-equation models commonly used in the literature on the degree to which the exchange rate fluctuations are passed on to domestic prices use first-difference estimators, thus excluding the terms that capture the long term relationship between import prices, foreign prices and domestic prices. The problem is that if a model's variables are cointegrated, the model is poorly specified and the results obtained from it are biased (De Bandt et al, 2008). Moreover, when, for their part, models of systems do not include the costs of the country of destination when they are used to calculate the coefficient of the long term pass-through to prices, they could lead to the violation of long term homogeneity, thus making the results of those studies incomparable. In such cases, the monetary authorities should be cautious about using them (Aron et al, 2014b).

This study follows Aron et al (2014a) and thus uses both a single-equation model and a structural VAR one; the latter model corrects the specification errors mentioned above. The single-equation model has seen a slight methodological innovation in standard models (as in Campa and Goldberg, 2005); it adds a long term equilibrium correction term and dynamic terms to the lags preceding the period for which the degree of the short- and the medium-term impact is calculated. This method makes

it possible to estimate the degree of the short term pass-through by simply using a single equation but without entirely ignoring the longer-term information, even though the exchange rate and the domestic costs are still assumed to be exogenous in the single-equation model. For its part, the structural VAR model incorporates various long term homogeneity restrictions while estimating, using the impulse response functions, the degree of the short term pass-through.

This study focuses on Kenya and Cameroon, two countries which have experienced many twists and turns concerning inflation, the exchange rate and monetary policy (Berg et al, 2013). In the case of Cameroon, even though inflation seems to be under control today, the country is still exposed to shocks to prices of imported products, as was witnessed in 2007.[6] As for Kenya, it underwent a period of high inflation between 2000 and 2012.[7] Kenya switched to a floating exchange rate regime in the early 1990s while Cameroon, which is in a fixed exchange rate regime, saw its currency devalued in 1994. The two countries are also engaged in an international commercial and financial liberalization process. Yet, these are two countries for which studies on the extent of the exchange rate pass-through to prices are scarce and the results on the extent of this phenomenon are mixed[8] (Choudhri and Hakura, 2006; Devereux and Yetman, 2008; Kiptui et al, 2005).

The research question for this study is: What is the extent of the exchange rate pass-through to domestic prices in Kenya and Cameroon? Thus, the study's aim is to examine the extent of the exchange rate pass-through to domestic prices in Cameroon and Kenya. More specifically, the study estimates the degree and the speed of this exchange rate pass-through in the two countries. It tests the hypothesis that the extent of the exchange rate pass-through to domestic prices in Kenya and Cameroon is incomplete and lagged.

The interest of this study is three-fold: first, it will provide estimations of the extent of the exchange rate pass-through to domestic prices that are useful for monetary policy in the two countries; second, it allows us to compare the effect of the exchange rate regimes and monetary policies on the extent of the exchange rate pass-through to prices; third, it takes into account the various criticisms levelled against previous studies, following Aron et al (2014a).

The rest of the paper is organized as follows: section 2 is a review of the literature on the exchange rate pass-through; section 3 presents stylized facts about exchange rates, inflation and monetary policy in Cameroon and Kenya; section 4 describes the methodology; section 5 presents the results; while section 6 concludes and makes economic policy recommendations.

2. Literature review

The issue of exchange rate pass-through to domestic prices has been the subject of a host of theoretical and empirical studies. These studies have generally addressed the issue in the form of the following specific questions: What is the extent of the exchange rate pass-through to the various domestic price indices? Why is this extent partial and why does it decline? Is it a micro or a macro phenomenon? Why is it lower for the inflation rate than for the prices of imports expressed in the importing country's currency? Why are there asymmetries and non-linearity in the relationship?

With reference to the theoretical studies, the early ones of them only studied the extent of the exchange rate pass-through to domestic prices and its dynamics. They were conducted at a microeconomic level and examined the extent of the pass-through to import prices (expressed in the importing country's currency) in specific sectors using disaggregated data (Goldberg and Knetter, 1997; Menon, 1995).

Since the beginning of the 2000s, the theoretical literature started to address the issue of the link between the extent of the exchange rate pass-through to domestic prices and monetary policy. The relevant theoretical studies can be divided into two groups: those based on macroeconomic models in the open economy and the controversial role of expenses transfer (change in the allocation) of the exchange rate, and those based on the Taylor model and its assumption of a declining degree of the exchange rate pass-through to domestic prices under credible monetary policy regimes.

The new open economy macroeconomic models (such as those of Obstfeld, 2002, and Engel, 2004), using fully-specified dynamic general equilibrium models with wage and price rigidity and different assumptions of price formation for businesses, show that assumptions about the extent of the ERPT considerably influence the effectiveness of monetary policy. In some models, the impact of the exchange rate pass-through is complete because the producer currency pricing (PCP)[9] is assumed. In this case, the exchange rate fully plays its role of changing the allocation of expenditure. However, these models have been contradicted by empirical evidence against a complete ERPT and against the theory of an exchange rate purchasing power parity implied in the PCP. In other variants of those models, the pricing to market (PTM)[10] is combined with the local currency pricing (LCP).[11] Then there is the case where the exchange rate no longer plays the standard role of expenditure transfer. Such a situation has potentially significant implications for the choice of the exchange rate regime (Aron et al., 2014b).

However, there are several theoretical and practical arguments for challenging the extreme cases of pricing in the importing country's currency and, thus, for reinstating the exchange rate's role of transfer of expenditure (Aron et al., 2014b). To complement the argument above, Bailliu and Fujii (2004) argue that if the economy is better characterized by a combination of firms – with some of them doing their pricing in the currency of the importing country and others doing it in that of the exporting country – then the overall extent of the pass-through will be partial (i.e. incomplete) in the short term. Similarly, as Mihaljek and Klau (2008) show, foreign exporters sell products to local importers/distributors at prices quoted in foreign currencies, and then the distributors resell them on the local market at prices quoted in the local currency. If they operate on a competitive market, the importers/distributors will partly absorb the effects of the exchange rate pass-through by adjusting their profit margins, which means that in the end the pass-through will be incomplete. The most relevant case is that of the small market economies in the industrialized and emerging economies and of the developing countries.

For those models, the extent of the exchange rate pass-through to prices is determined by microeconomic factors that are exogenous to monetary policy. According to the same models, other reasons may explain the decline in the exchange rate pass-through: a high degree of trade integration, changes in the market structure (due to globalization), and the weight of the consumer price index components.

Taylor (2000) uses a theory with imperfect competition which gives a certain control over the prices for firms. The author explains the relationship between inflation and the exchange rate movements by employing a model of firm behaviour based on monopolistic competition and staggered price setting. Taylor's model conjectures that with a low inflation and a lower inflation persistence, the firms' pricing power will be reduced, thus reducing their ability to pass on increased costs, including those arising from the exchange rate movements. It follows from this conjecture that the degree of price variations will depend on whether or not the exchange rate movements are permanent. These movements affect the marginal cost, but if they are perceived to be temporary, they will have little effect on the extent to which they will be passed on to prices (Froot and Klemperer, 1989). Taylor argues that maintaining a low and stable inflation induces a low degree of its transmission to prices, which in turn leads to low inflation. This argument is consistent with the adoption of the most credible monetary policy regimes that have contributed to stabilizing the inflationary expectations (that is, by lowering the movements in the expected producer costs). Thus, according to Taylor, the ERPT is endogenous to monetary policy.

Turning now to empirical studies, the standard (traditional) models assume the linearity and stability of parameters. An almost uniform finding of these empirical studies concerning the extent of the exchange rate pass-through to domestic prices is that this pass-through is partial and lagged (with the lags sometimes being considerable) in the short term (Aron et al., 2014b). This finding was confirmed for the developed countries by Campa and Goldberg (2002; 2008), for the emerging economies by Mihaljek and Klau (2001; 2008), and for the developing countries by

Akofio-Sowah (2009) and Razafimahefa (2012). The same finding was confirmed, for the long term, by Barhoumi (2006) for the emerging economies specifically in relation to the extent of the exchange rate pass-through to commercial prices (import prices and producer prices).

Another important finding reported in the empirical literature is that the extent of the exchange rate pass-through declines along the prices of the distribution chain. Indeed, the degree of the pass-through to import prices is higher than that to producer prices, which in turn is higher than that to consumer prices (Choudhri and Hakura, 2006; Ca' Zorzi et al, 2007). The extent of the exchange rate pass-through to domestic prices strongly varies from one country to another in the case of industrialized countries and emerging economies. It was also found to be influenced by both macroeconomic and microeconomic factors, some of which are more important than others for the emerging economies, compared to the developed countries (Bussière and Peltonen, 2008; Brun-Aguerre et al, 2012).

A large part of the empirical literature agrees with Taylor's (2000) hypothesis that the pass-through to prices will decline in a low inflation environment (Choudhri and Hakura, 2006; Ca' Zorzi and al, 2007; Bailliu and Fujii, 2004). Recently, empirical studies have challenged the linearity of the price response to the exchange rate movements by testing for size and direction asymmetries in the relationship between the exchange rate and domestic prices (Pollard and Coughlin, 2003; Campa and Goldberg, 2008; Bussière, 2007; Razafimahefa, 2012; Mihaljek and Klau, 2008; Brun-Aguerre et al, 2012; Lopez-Villavicencio and Mignon, 2016; Caselli and Roitman, 2016). All of these studies found significant asymmetries.

The instability of the parameters in a sample was also tested. Studies have shown that fixed exchange rate regimes experience a higher degree of price pass-through than flexible exchange rate ones. In addition, a positive relationship has been shown to exist between average inflation and the pass-through. Thus, low-inflation regimes are characterized by a low degree of pass-through. Finally, the more open an economy is, the higher the degree of pass-through it experiences.

Very few studies have tested those different hypotheses in the case of African countries. Nevertheless, there has been a growing interest in analysing the extent of the exchange rate pass-through to domestic prices. Ogun (2000) conducted a study on the Nigerian economy and found that 93% of the exchange rate fluctuations were passed on to the price of the country's manufactured exports. Bhundia (2002) studied the case of South Africa and found that the degree of price pass-through was low. Mwase (2006) studied the pass-through phenomenon in Tanzania and found that its degree was low in a significant way. Frimpong (2010) and Sanusi (2010) found that the extent of the pass-through to consumer prices was incomplete in Ghana. More recently, Fatai and Akinbobola (2015) found that the ERPT was significant, moderate and persistent for import prices, but short-lived and of a low level for inflation.

Concerning studies on groups of countries, Choudhri and Hakura (2006) found that the extent of the exchange rate pass-through to prices was incomplete for African countries, except for Ethiopia (where it was reported to be zero, but this was due to

an error). Akofio-Sowah (2009) found that trade openness and country size did not influence the degree of the pass-through to prices; instead, a positive relationship was found between this degree and the exchange rate volatility. The author agreed with Taylor's hypothesis (2000). Razafimahefa (2012) found that the degree of the price pass-through was higher in countries with a fixed exchange rate than in those with floating exchange rate regimes.

Most of the studies covering Cameroon and Kenya were based on time series and multi-country data. For example, Choudhri and Hakura (2006), in a time-series study covering the period from 1979 to 2000 found the degree of the pass-through in the case of Kenya to be 9%, 22%, 35% and 38% for the current quarter, the first quarter, the fourth quarter, and the twentieth quarter, respectively; in the case of Cameroon, they found it to be 22%, 32%, 38% and 39% for the corresponding respective quarters. For their part, Devereux and Yetman (2008) found that the pass-through was incomplete in the long term in the case of Kenya, amounting to a degree of 53% while it amounted to 14% in the case of Cameroon. Razafimahefa (2012) found that the degree of the exchange rate pass-through to prices in Cameroon was incomplete and amounted to 27.6%, 54.8% and 55.4% for the first quarter, the fourth quarter, and the eighth quarter, respectively.

Kiptui et al (2005) study is the only one conducted exclusively about Kenya.[12] The study found that the long term pass-through to prices during the 1972-2002 period was incomplete, at a degree of 71%. It also found that while an exchange rate shock led to a sharp rise in the CPI inflation, the effect disappeared after four years. The exchange rate shocks represented 46% of the inflation rate fluctuations in the first year and had reached 57% in the third year. The study further found that the short term pass-through was incomplete, at a degree of 69%, since a falling exchange rate had a positive impact on import prices. This finding was corroborated by variance decomposition estimations which showed that exchange rate shocks accounted for 76% of the import price fluctuations in the first period.

It transpires from the literature reviewed above that the results on the degree of the exchange rate pass-through to domestic prices in Cameroon and Kenya are mixed. Moreover, the most-often cited studies suffer from several specification errors, among which the omission of the control variables that are correlated to the exchange rates. Such an omission renders comparisons impossible and, as a result, informed monetary authorities should be cautious about those findings (Aron et al, 2014b). Such a limitation of the previous studies justifies further research in the area.

3. Comparative analysis of Kenya and Cameroon

This study focuses on Cameroon and Kenya for a comparative analysis because the two countries are the two largest economies in Central Africa and East Africa, respectively. Moreover, the two countries of interest are representative of low-income sub-Saharan African countries (which means that they each have a rich and unique history). The structure of their economy is indeed typical of sub-Saharan African economies: these are characterized by a small share in the world trade (basically consisting of raw materials exports), by a high dependence on imports, by a GDP driven by the service sector, by a large agricultural sector, and by a predominant rural population, as shown in Table 1.

Table 1: Key economic indicators[13]

Country	Exports (as a % of GDP)	Imports (as a % of GDP)	Rural population (as a % of the total)	Raw materials exports (as % of the total exports)	Value added of the service sector
Cameroon	21.73	31.15	45.61	> 50	47.77%
Kenya	16.4	33.87	74.38	> 50	50.37%

Source: World Bank World Development Indicators and IMF data

The fact that both countries import more than they export, as can be seen in Table 1 and as confirmed by the trends in their import and export volumes (in Annex Table A.1), is an indication that they are both exposed to exchange rate fluctuations. According to Akofio-Sowah (2009), the very definition of trade openness is the sum of exports and imports of goods and services measured as a percentage of GDP. Thus, the more open a given country's economy is (i.e. marked by a strong presence of imports and exports), the more the exchange rate fluctuations are transmitted from import prices to domestic prices. Cameroon and Kenya have put in place trade and industry policies[14] aimed at encouraging trade openness and competition within their respective economies. Openness of an economy allows for greater foreign actors' participation and for increased capital inflows and imports of intermediate and final goods and services.

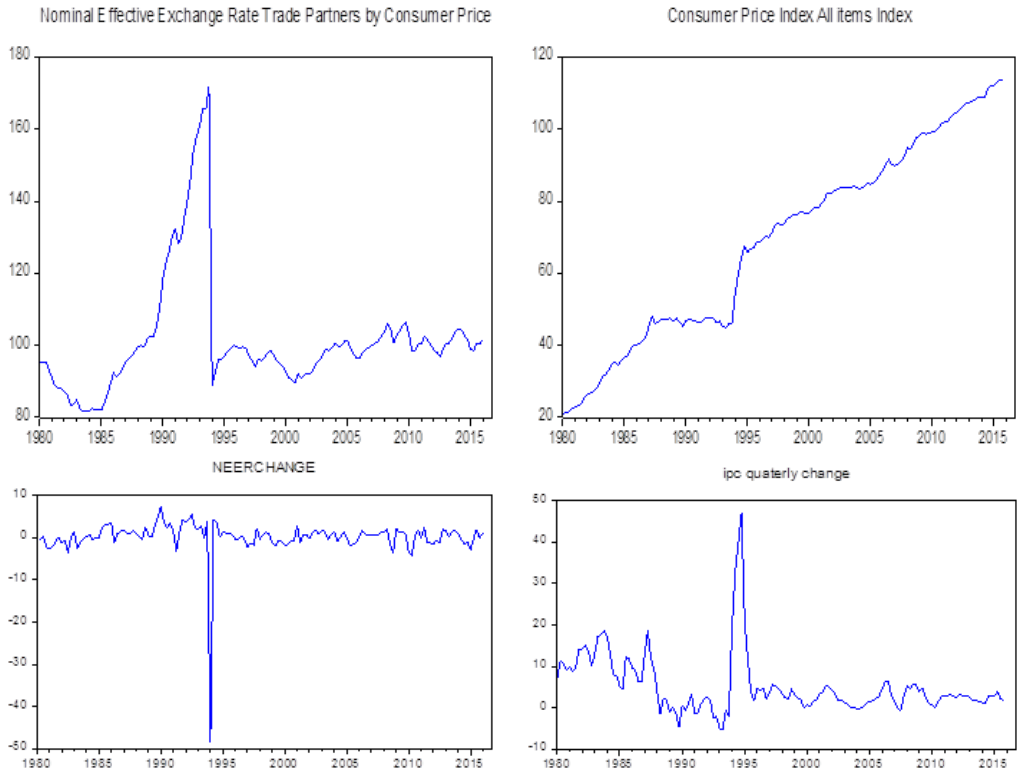
Over the last three decades, inflation has fluctuated greatly in the two countries. In the case of Cameroon, the annual average over that period was 4.59%, with a standard deviation of 5.87%. It reached its lowest value (-3.71%) on the eve of the 1994 CFA franc devaluation, after which it registered its highest value (25.8%). In the aftermath of the increase in food prices in 2007, Cameroon experienced its highest rise in inflation (5.35%) during the current decade and although it has been fluctuating, it has remained lower than 3% for the last four years.

Inflation in Kenya also went up and down over the period under study. With an average of 11.35% and a standard deviation of 7.90% during that period, inflation in Kenya was always above 5% (with the exception of four years: 1988, 1995, 2002, and 2004), which was the target of the Central Bank of Kenya (CBK). The IMF (2009) considered that between 1995 and 2009, Kenya experienced the most severe episode in terms of inflation. Yet, the inflation rate continued to rise and reached 16% in 2012. This high volatility of Kenyan inflation is attributable to the high share of food prices in the country's overall CPI, to its low agricultural production, high energy prices, the depreciation of the local currency (the shilling), and to monetary conditions (IMF, 2009).

In terms of exchange rate and monetary regimes, the exchange rate is measured by the nominal effective exchange rate. Kenya moved from a fixed exchange rate regime to a floating exchange rate one in the early 1990s. The move exposed its currency to domestic and external shocks, thus increasing its volatility. Over the period, on average the exchange rate varied by 1.53% with a standard deviation of 3%. The maximum level reached was 7% while the minimum was -4.8%. In the case of Cameroon, where the exchange rate regime is fixed, the CFA franc was devalued in 1994 by 50% and, later in 1999, it was pegged to the Euro. The country's central bank must intervene to maintain its (main) objective, namely the stability of the exchange rate of the currency on the foreign exchange market: "an adequate rate for currency hedging (with the minimum threshold being 20%)" [see the BEAC monetary policy statement]. For its part, Kenya's monetary policy is a hybrid system in that it combines elements of the monetary targeting framework with the element of inflation targeting.

In the case of Cameroon, the correlation coefficient between the exchange rate fluctuations and those of the inflation rate was -0.6674 over the study period, and the inflation rate fluctuations are generally higher than the exchange rate ones. A similar observation was made for Kenya where the correlation coefficient was -0.705 over the period. In general, the inflation rate in Kenya has always been higher than that in Cameroon, and this remains true even when the exchange rate fluctuations are taken into account. Figures 1 and 2 show the trends in the nominal effective exchange rate and the rate of inflation between 1980 and 2016.

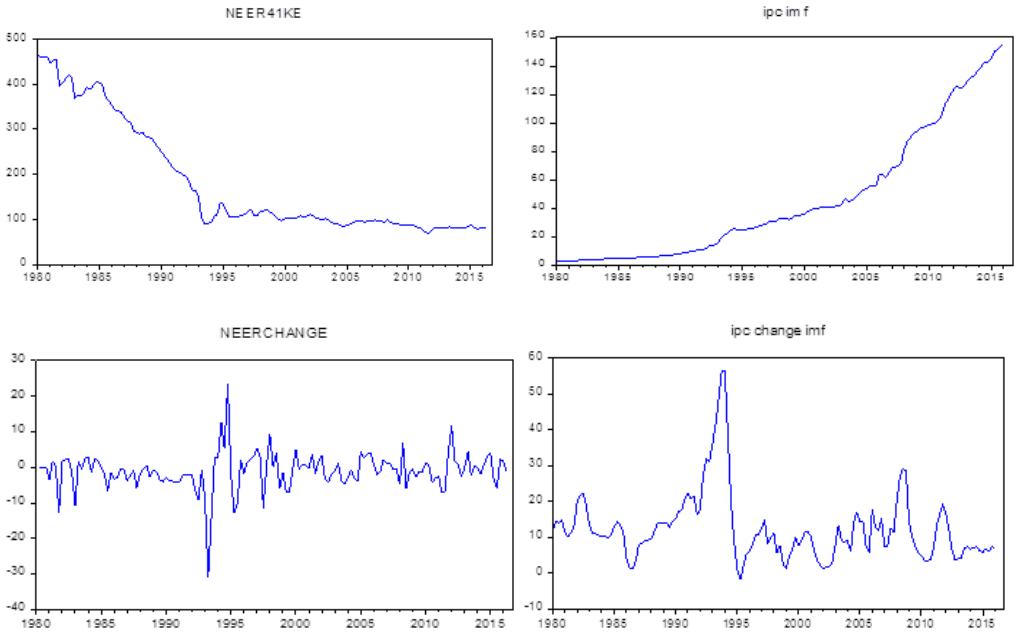
Figure 1: Trends in the exchange rate and the inflation rate in absolute and relative values in Cameroon



Source: IMF data

It can clearly be seen that fluctuations in the inflation rate are generally higher than those in the exchange rate in Cameroon. The same observation can be made for Kenya. The biggest change in the exchange rate in Cameroon was the devaluation of the CFAF in 1994 and was at the same time the biggest change in the inflation rate in the same year. In Kenya, when the exchange rate fluctuated by about 30% in early 1993,[15] the inflation rate fluctuated by almost 50% at the end of that year. And when the nominal effective exchange rate (NEER) decreased, the consumer price index increased. This suggests that the exchange rate fluctuations might have been transmitted, to some extent, to domestic prices.

Figure 2: Trends in the exchange rate and the inflation rate in absolute and relative values in Kenya



Source: Data from the IMF and BRUEGEL

4. Empirical framework

Overview

The empirical specification used in this study is based on a reduced-form equation of the mark-up widely used for empirical analysis of the extent of the exchange rate pass-through to aggregate and disaggregated prices. Aron et al (2014a, 2014b) provide an overview of this model that generalizes Campa and Goldberg's (2005) formulation by incorporating the domestic relative costs of the country of destination into the mark-up function and the exogenous prices of commodities into the exporter's marginal cost function.

This can be expressed in the form of a long-term log-linear regression specification, with domestic prices (import prices, consumer price index) being determined by the nominal exchange rate, by domestic and foreign costs, and by demand variables.

$$p_t^m = \lambda + \beta e_t + \alpha_1 w_t^x + \alpha_2 pcom_t^x + \alpha_3 w_t^m + \alpha_4 y_t^x + \alpha_5 y_t^m + \varepsilon_t \quad (1)$$

In this equation, for the logarithmic variables, p^m is the consumer price index (CPI) in local currency, λ is a constant, e is the (nominal) exchange rate, w^x and w^m are control variables representing export costs and domestic costs, respectively, $pcom^x$ represents another element of export costs arising specifically from commodity prices, such as oil prices, and y^x and y^m are controls for the real gross domestic product (GDP) of the destination market and the export market, respectively. The omission of control variables that are correlated with the exchange rate could produce biased estimations of the pass-through coefficient, β.

The plausible restrictions of Equation 1 are the following: (i) the long-term homogeneity (illusion of lack of money) at a given exchange rate implies that $1= \alpha_1 + \alpha_2 + \alpha_3$; (ii) the long-term homogeneity that takes into account the exchange rate fluctuations implies that $\beta = -(\alpha_1+\alpha_2)$. Therefore, the degree of the long term pass-through to prices is measured by $\beta = -(1-\alpha_3)$.

In the short term, these long-term restrictions may not be respected. At one extreme, full long-term pricing aimed at the domestic market (i.e. the local currency pricing, LCP) would imply that $\beta=0$ and that exporters will fully absorb the exchange

rate fluctuations in their profit margins. At the other extreme, a complete pass-through to prices (i.e. the producer currency pricing, PCP) would mean that β =-1 and α_3=0. It should be noted that the long term is defined here with reference to domestic costs (typically the unit labour costs for domestic workers). In the long term, these costs could themselves be influenced by the exchange rate and foreign prices, which would increase the degree of the long term pass-through to import prices.

Equation 1 is treated in various ways in the empirical literature (see Aron et al, 2014b).[16] In one approach, Equation 1 is estimated as a single equation, treating the exchange rate and domestic costs as exogenous, to represent the extent of the long term price pass-through represented by β. These variables could be treated as forming a single cointegration relationship. However, to be correct, the Johansen method (system of equations) should be used to test for the existence of multiple cointegration vectors (Johansen, 1988; Johansen and Juselius, 1990) to deal with the exchange rate and domestic costs as potentially endogenous. To determine the extent of the medium-term price pass-through, for example after one year, identification restrictions must be imposed to generate impulse response functions in a single-shock unitary exchange rate system. In this way, the pass-through coefficients for different lags can be obtained from the cumulative impulse response function.

In other studies, the possibility of a long-term relationship is removed (or is not found in a test). Instead, a first-difference version of this single-equation relationship is estimated for subsets of the control variables (see e.g. Campa and Goldberg, 2005) and with up to n lags for the different variables to allow a gradual adjustment of the exchange rate.

$$p_t^m = \lambda + \beta e_t + \alpha_1 w_t^x + \alpha_2 pcom_t^x + \alpha_3 w_t^m + \alpha_4 y_t^x + \alpha_5 y_t^m + \varepsilon_t \quad (2)$$

In this case, the short term pass-through (after one period) is given by -β_0 while the medium-term elasticity is given by - $\sum_{i=0}^{n-1} \beta_i$ for the pass-through up to n periods. For example, if n is 4 and quarterly data are used, this measure will give the extent of the price pass-through after one year. If the changes in the log of the exchange rate are exogenous, and the permanent shocks and the other variables in Equation 2 are exogenous as well, then $\sum_{i=0}^{n-1} \beta_i$ will approximate the cumulative impulse response function up to n periods.

In the empirical application of this study, this approximation gets improved without losing the simplicity in computing the pass-through by controlling for the lagged long term information, including information on endogenous consumer prices, dated as t-n or a longer period, where n is the period for which the extent of the price pass-through is measured. Incorporating the relevant exogenous control variables, such as commodity prices, should further enhance the efficiency of the β_is estimated from the regression of Equation 2.

Measures used for the variables and sources of data

This study used seven variables to carry out a single-equation econometric estimation for both countries: the consumer price index, the exchange rate, the GDP per person employed at the market cost and the quarterly growth of the real GDP (both as proxies of domestic costs and demand), and foreign prices and the EU countries industrial production index (both as proxies of foreign costs and demand).

The dependent variable is the quarterly consumer price index (CPI). The main explanatory variable is the nominal effective exchange rate (NEER) derived from the BRUEGEL,[17] [18] database; the NEER is defined in a way that an increase refers to an appreciation. In relation to control variables, the study followed Campa and Goldberg (2005), who observed that it was difficult to find a primary control variable capable of capturing the fluctuating relative costs of a country's aggregated trading partners. Following the two authors, in this study proxies of foreign costs are constructed that are weighted as a function of a country's trade with its trading partners by calculating w^x in equation (1) as $w^x = logNEER + logP - logREER$. The corresponding real effective exchange rate comes from the BRUEGEL database on the exchange rate, which takes into account the weight of bilateral trade between the African countries concerned (in this case Kenya and Cameroon) and each of their trading partners (Zsolt, 2012). In addition to using price proxies for costs, this study follows Marazzi et al (2005) and adds a measure of commodity prices, in this case oil prices in dollars, $pcom^x$. The prices of petrol and other derived fuels included in imports, and domestic prices, lag behind the fluctuations in crude oil prices. Moreover, since the import price index includes crude oil, it is important to control for fluctuations in oil prices.

This study is the first to have included commodity prices for Cameroon and Kenya in its calculation of the price pass-through coefficient. Commodity prices have been added to take into account the other foreign-currency costs and the side effects on supply, and thus to dissociate them from the exogenous effects of the exchange rate. The domestic costs have been controlled for using the GDP per person employed[19] (at the market cost), w^m. Most studies have ignored the costs in the destination country, such as the unit labour costs. Not using controls for domestic costs is particularly detrimental to CPI equations, especially in relation to monthly frequencies, as wage shocks are very likely in emerging economies and developing countries.[20] Not using them will lead to a violation of the long term price homogeneity (Aron et al, 2014b). The study further controls for the foreign and domestic demand variables, among them quarterly growth rate of the real GDP (y^m), and the industrial production index for European Union countries (y^x). These countries are indeed Cameroon's and Kenya's main trading partners. In accordance with Equation 1, all the study's variables are expressed in logarithm.

The single-equation econometric estimations for both countries have been complemented by a multiple-equation model, specifically a structural VAR (the technical details of which can be found in Table A.3). The SVAR model, unlike the

single-equation one, takes into account the potential compensatory reaction that affects the domestic costs and the exchange rate (for example, monetary policy), since these variables are endogenous. Five variables will be used in this VAR, namely p^{comx}, w^m, M2, e, and p^m. The money supply (M2) will be included in the VAR to allow for the reaction of monetary policy on the consumer price index, in response to a strong fluctuation in the exchange rate or to devaluation.

The start date (1991) and the end date (2013) used as the reference in this study were chosen for data availability. The data were obtained from the World Bank World Development Indicators (WDI), the BRUEGEL Exchange Rate Database, and the IMF International Financial Statistics (IFS).

The results of the stationarity tests (detailed in Table A.2) used to measure our variables show that:

- for Cameroon, the variables w^m and M2 are stationary in levels I(0), whereas p, e, w^x, $pcom^x$, y^x and y^m are stationary in first differences I(1); and,

- for Kenya, the variables w^m and M2 are stationary in levels in I(0), whereas p, e, w^m, $pcom^x$, y^x and y^m are stationary in first differences I (1).

Methodology

The study tested different models at quarterly frequencies. As pointed out earlier, a small methodological innovation in single-equation models has made it possible to calculate the short term pass-through by controlling for domestic demand, for foreign and domestic costs, but without ignoring the information in the long term equilibrium term and the lagged dependent variable.

The first models were differentiated[21] with the degree of the price pass-through over a year given by $\sum_{i=0}^{3} \beta_i$,

$$\Delta p_t^m = c + \sum_{i=0}^{n} [\beta_i \Delta e_{t-i} + \alpha_{1i} \Delta w_{t-i}^x + \alpha_{2i} \Delta pcom_{t-i}^x + \alpha_{3i} \Delta w_{t-i}^m + \alpha_{4i} \Delta y_{t-i}^x + \alpha_{5i} \Delta y_{t-i}^m + \alpha_{6i} \Delta p_{t-i-4}^m] + \varepsilon_t \quad (3)$$

The expected signs were found to be negative for the exchange rate fluctuations (an increase corresponds to appreciation), but positive for the oil price fluctuations, for the foreign and domestic costs, and for the increase in the demand. The term for the lagged dependent variable can only be included before the maximum lag (four quarters) for the exchange rate, otherwise it would not be possible to calculate the extent of the price pass-through over four quarters based on $\sum_{i=0}^{3} \beta_i$.[22]

The regression specification used in Campa and Goldberg (2005) was also used with quarterly data; it uses fewer controls than Equation 3 above. The study chose to control for the local demand conditions by using the real GDP growth rate (which is a demand proxy commonly used in the literature) because it is the same rate that the study has already used in its other equations.

$$\Delta p_t^m = c + \sum_0^3 \beta_i \Delta e_{t-i} + \sum_0^3 \alpha_{1i} \Delta w_{t-i}^x + \alpha_5 \Delta_3 y^m{}_t + \varepsilon_t \quad (4)$$

The next step consists in examining better-defined models; that is those using terms for domestic and foreign prices that require a long term price homogeneity. The composite equilibrium correction term is represented in Equation 5:

$$ecm_{t-4} = [\alpha_1(w_{t-4}^x - e_{t-4}) + \alpha_2(pcom_{t-4}^x - e_{t-4}) + \alpha_3 w_{t-4}^m - p_{t-4}^m \quad (5)$$

where foreign prices have been converted into the destination country's currency and α_1+α_2+α_3=1. Incorporating the equilibrium correction term into a single equation gives the adjustment speed γ.

$$\Delta p_t^m = c + \gamma ecm_{t-4} + \sum_{i=0}^3 [\beta_i \Delta e_{t-i} + \alpha_{1i} \Delta w_{t-i}^x + \alpha_{2i} \Delta pcom_{t-i}^x + \alpha_{3i} \Delta w_{t-i}^m + \alpha_{4i} \Delta y_{t-i}^x + \alpha_{5i} \Delta y_{t-i}^m + \alpha_{6i} \Delta p_{t-i-4}^m] + \varepsilon_t \quad (6)$$

To obtain, through simple computation, the extent of the price pass-through over four quarters of $\sum_{i=0}^3 \beta_i$, the equilibrium correction term in this single equation can only be incorporated before the maximum of (four) lags in the exchange rate. A poor specification that is common in single-equation models and is due to the omission of the long term terms, is thus partially resolved by incorporating the lag of the equilibrium correction term. Incorporating any information that is dated to t-4 or earlier should enhance the accuracy of the estimation or approximation of $\sum_{i=0}^3 \beta_i$.

It should be remembered that the results of the stationarity tests presented earlier allow us to estimate Equation 6. Indeed, this equation represents an unrestricted error-correction model (ECM), which is a particular form of the autoregressive distributed lag (ARDL)[23] models, traditionally used in the literature on the extent of the exchange rate pass-through to prices.

All in all, this study has adopted an approach of systems of equations to be thorough. The degree of the long term pass-through to prices was estimated, and the short term pass-through was calculated from the impulse response functions that were

generated from a structural VAR (see details in Table A.3), identified by a number of theoretically motivated restrictions[24] (Bwire et al, 2013). The results obtained can be compared with those of the single-equation method which assumes the heterogeneity of the variables on the right side of the model, including the exchange rate, while the system-based (VAR) method allows for restricted interactions in all the plausible economic directions among the endogenous variables.

5. Results

This study sought to answer the question of what the magnitude and speed of the extent of the exchange rate pass-through to the consumer price index was. It used different models involving various single-equation specifications and the estimation of a structural VAR model.

ECM and ARDL Approaches

Magnitude and speed of the extent of exchange rate pass-through to the consumer price index

The study first tested the cointegration relationship between the variables for either country. To this end, it used the ARDL bounds test since some of the series in the study are zero-order integrated. The results of the tests (detailed in Annex Table A.4) show that the series are cointegrated, since the calculated F-statistic, for either country, is higher than the upper limit of the critical values at all the significance thresholds. The study then estimated the ARDL in levels to obtain the long term pass-through coefficients. Table 2 presents the results for both countries.

Table 2: Dependent variable: Consumer price index

Cameroon				Kenya			
Independent variables	Coeff-icients	t-ratio	p-values	Independent variables	Coeff-icients	t-ratio	p-values
e	-0.283	-2.145	0.035	e	-1.061	-4.353	0.000
px	0.192	2.897	0.005	px	-0.039	-1.074	0.286
wx	0.178	7.807	0.000	wx	0.204	1.489	0.141
wm	-0.517	-2.073	0.042	wm	1.517	1.431	0.156
yx	0.823	3.540	0.001	yx	-0.246	-0.533	0.595
ym	0.079	2.184	0.032	ym	0.069	1.004	0.319

The results reported in Table 2 show that the exchange rate had a significant effect on the long term consumer price index in both countries. Its effect was greater in

Kenya than in Cameroon, since a 1% fluctuation in the exchange rate caused a 0.28% fluctuation in the consumer price index in Cameroon and 1.06% in Kenya. The other five explanatory variables were found to be significant in the case of Cameroon, while they were not significant in the case of Kenya.

The pass-through coefficients between the first and fourth quarters are presented in tables 3 and 4 for the full sample between 1991.1 and 2013.4. Columns 1-4 report general equations without a reduction to parsimonious equations. Columns 1 and 2 present Equation 3 first without and then with the dependent variable lagged (at a lag of four quarters). Column 3 reports the Campa-Goldberg specification in quarterly data, as in Equation 4. Column 4 presents the equilibrium correction model of Equation 6. Column 5 presents the estimation of an ARDL model with an automatic selection of dynamic regressors from the general equilibrium correction model in Equation 6.

All the study's models were subjected to the usual diagnostic tests such as residue tests (normality, autocorrelation, and heteroscedasticity), the Ramsey-Reset-model good specification test, and the CUSUM and CUSUM-of-squares tests. Overall, the models' errors were found to be non-correlated and homoscedastic, but not normal; the models were found to be well specified, structurally stable and at times unstable (see the results in Annex Table A.4).

Table 3 summarizes the results for Kenya. It shows that the degree of the short term price pass-through varied from -0.14 to -0.2 depending on the model, while the degree of the (medium-term) price pass-through over one year varied between -0.16 and -0.58 depending on the model.

These results mean that in the case of Kenya, a 1% fluctuation in the exchange rate resulted in a 0.2% fluctuation in the consumer price index in the short term and of 0.58% in the medium term. The results also show that the error correction coefficient (or the restoring force towards equilibrium) was equal to -0.16, which means that after straying from the equilibrium trajectory, the return occurred at the next period at 0.16%. Foreign and domestic costs, and domestic demand, were significant in the short term.

The results for Cameroon are summarized in Table 4. The table shows that the degree of the short term pass-through to prices was -0.29 except in the case of the Campa and Goldberg specification. For the medium term (one year), the same degree varied between -0.53 and -0.89. This means that a 1% fluctuation in the exchange rate led to a fluctuation in the CPI of 0.29% in the short term and of 0.89% in the medium term. These values are higher than those obtained for Kenya, which confirms the theory that exchange rate fluctuations are transmitted to prices in a fixed exchange rate regime at a higher degree than to those in a flexible exchange rate regime. The error correction coefficient was found to be 0.15. As for the control variables, the price of oil, foreign costs, and domestic and foreign demands, they were found to be significant in the short term.

Table 3: Degree of the exchange rate pass-through to prices in Kenya

Column	1	2	3	4	5
Model	Differentiated equation without a lagged dependent variable	Differentiated equation with a lagged dependent variable	Campa and Goldberg specification	Equilibrium-correction model: error correction term at t-4	ARDL with automatic selection
Equation No.	3	3	4	6	6
Dependent variable: inflation (as measured by the consumer price index)					
Δe_t	-0.14	-0.15	-0.16	-0.2	-0.16
	(-2.19)	(-2.34)	(-3.7)	(-2.88)	(-3.5)
Δe_{t-1}	-0.05	-0.12	-0.09	0.05	
		(-1.75)	(-1.84)		
Δe_{t-2}	-0.05	-0.14	-0.08	-0.03	
		(-1.90)	(-1.79)		
Δe_{t-3}	-0.13	-0.17	-0.14	-0.05	
	(-1.91)	(-2.29)	(-3.31)		
$\sum_{i=0}^{3} \beta_i$	-0.37	-0.58	-0.47	-0.33	
Ect (-1)				-0.14	-0.16
				(-3.72)	(-7.1)
R^2/R^2 adjusted	0.59/0.35	0.71/0.47	0.31/0.24	0.76/0.54	

Source: Author's compilation. The values in parentheses are student's statistics (t-ratio)

To ensure the robustness of the study's results, an indicator (dummy) variable was introduced into each model and for either country to account for the obvious structural changes for either country, notably the CFAF devaluation in January 1994 in the case of Cameroon and the change in the exchange rate regime in October 1993 in the case of Kenya. Specifically, the variable takes the value 0 up to the first quarter of 1994 and 1 after that in the case of Cameroon; it takes the value 0 up to the fourth quarter of 1993 and 1 after that in the case of Kenya. The models were later re-estimated and the results found were almost identical to those that were obtained before,[25] thus attesting to the quality and reliability of the models.

Overall, the study's results are consistent with the literature on short- and medium-term exchange rate regimes, but not with that on long term ones. They are also consistent with the literature on long term inflation, but not with that on inflation in the short term and in the medium term. This can be explained by the fact that, whether in the case of Kenya or that of Cameroon, the exchange rate shocks are considered a permanent feature, and there have been changes in the composition

of the two countries' trade partners; increasingly, the two are doing more trade with Asian countries.

Table 4: Degree of the exchange rate pass-through to prices in Cameroon

Column	1	2	3	4	5
Model	Differentiated equation without a lagged dependent variable	Differentiated equation with a lagged dependent variable	Campa and Goldberg specification	Equilibrium-correction model: error correction term at t-4	ARDL with automatic selection
Equation No.	3	3	4	6	6
Dependent variable: inflation (as measured by the consumer price index)					
Δe_t	-0.29	-0.29	-0.24	-0.29	-0.29
	(-14.03)	(-13.6)	(-8.93)	(-13.61)	(-18.34)
$\Delta e\_(t-1)$	-0.14	-0.2	-0.1	-0.2	-0.22
	(-6.91)	(-4.8)	(-3.65)	(-4.26)	(-7.71)
$\Delta e\_(t-2)$	-0.14	-0.2	-0.12	-0.22	-0.23
	(-6.6)	(-4.87)	(-4.37)	(-5.26)	(-8.35)
$\Delta e\_(t-3)$	-0.07	-0.12	-0.07	-0.16	-0.15
	(-3.19)	(-2.9)	(-2.47)	(-4.0)	(-6.78)
$\sum_{i=0}^{3} \beta_i$	-0.64	-0.71	-0.53	-0.87	-0.89
Ect (-1)				-0.1	-0.15
				(-3.07)	(-10.17)
R^2/R^2 adjusted	0.87/0.81	0.88/0.82	0.54/0.51	0.92/0.87	

Source: Author's compilation. The values in parentheses are student's statistics (t-ratio)

VAR Method

Estimations of the extent of the exchange rate pass-through to prices based on single-equation models imply that the exchange rate fluctuations are permanent exogenous shocks and that there is no relationship between shocks to the different variables. Models of systems, for their part, allow for the endogeneity of the variables. They thus make it possible to measure the feedback effects between the variables.

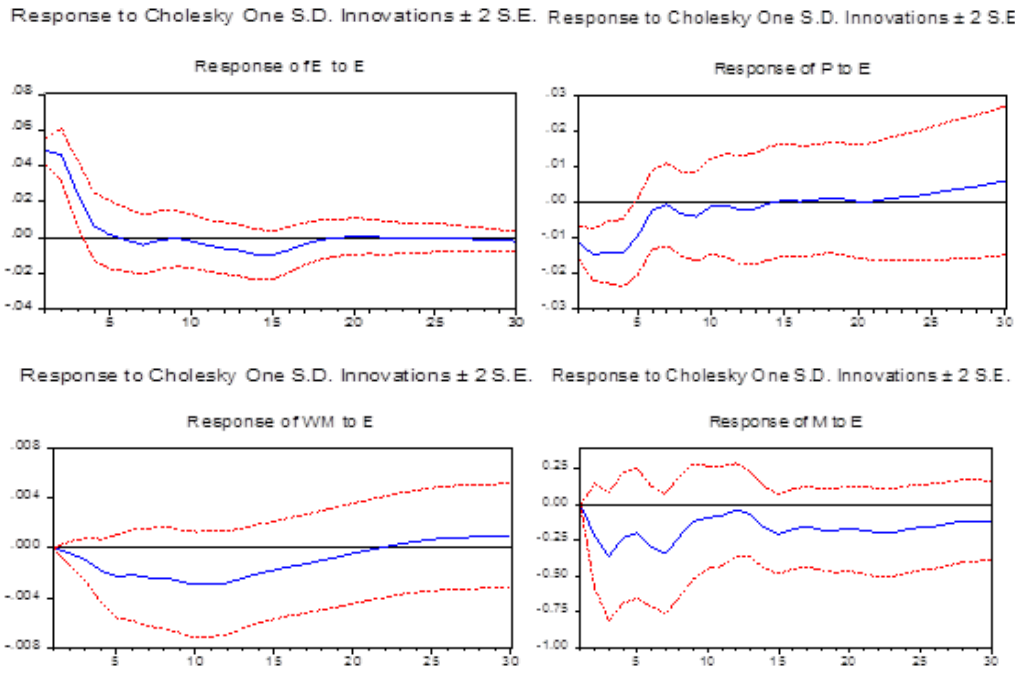
The study's model used the following five variables: the price of oil, the quarterly growth rate of the real GDP, money supply (represented by M2), the nominal effective

exchange rate, and the consumer price index. It applied the usual tests to the residues of models (LM test) to determine the number of lags that are appropriate for the model's data (six for Kenya and seven for Cameroon). It also applied the cointegration test (see Annex Table A.5) to the variables, which showed that the series were cointegrated in both countries. Then the study focused on estimating the impulse response functions and variance decomposition.

Impulse response function

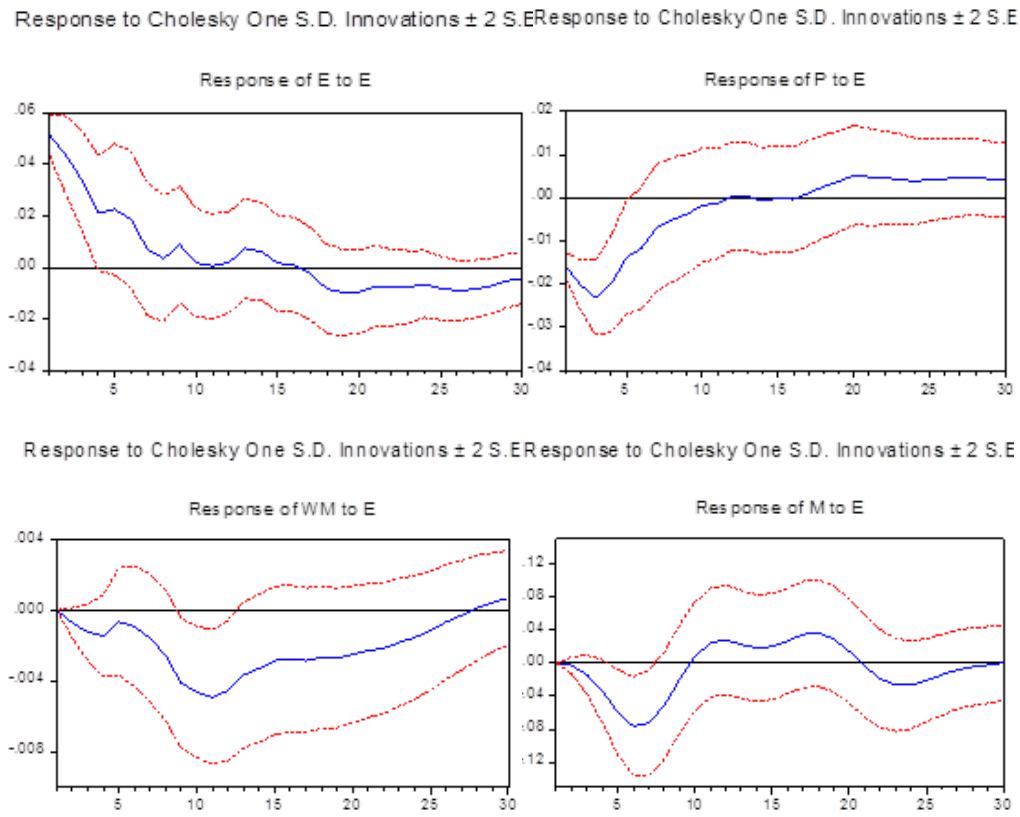
The results of the exchange rate shocks according to the following identification equation p^{comx} w^{m} $m2$ e p are presented in figures 3 and 4. These figures show the impact of a 1 standard-deviation shock, defined as an exogenous, unexpected and temporary depreciation of the exchange rate with a 95% confidence level, related to the domestic price inflation, to the quarterly growth rate of the real GDP, the price of oil, and the money supply at period 0. The solid line in each graph is the estimated response while the dashed lines indicate a confidence interval of two standard errors around the estimated value.

Figure 3: Response to an exchange rate structural shock in Kenya



Source: Author's compilation

Figure 4: Response to an exchange rate structural shock in Cameroon



Source: Author's compilation

It can clearly be seen that the impact of an exchange rate shock on domestic prices in both countries was gradual (it took about four quarters to reach its full effect) and persistent. The figures in the impulse response tables show that in the case of Kenya, the immediate effect of a one-standard-deviation structural shock to an exchange rate of 0.048 (or 4.8%) was about a 0.011 (or 1.1%) increase in domestic prices. This suggests a 0.23 impact of the elasticity of the degree of the price pass-through. The full effect of this shock between the second and fourth quarters was about a 0.015 (or 1.5%) increase in domestic prices, which suggests a 0.3125 dynamic elasticity of the degree of the price pass-through. This effect slowed down afterwards, but persisted in the long term. With regard to the central bank's reaction, the figure indicate that the temporary unexpected depreciation of the exchange rate was followed by a tightening of monetary policy (with a peak impact in the third quarter). After that, the central bank relaxed its reaction (most likely because it was informed by a relaxation of the corresponding inflation) and ultimately settled on its equilibrium path in the long term. The quarterly growth rate of the real GDP reacted to the exchange rate shock by declining, with its volatility disappearing at the end of the quarter.

In the case of Cameroon, the immediate effect of a one-standard-deviation structural shock to an exchange rate of 0.051 (or 5.1%) was about a 0.016 (or 1.6%) increase in domestic prices. This suggests a 0.314 effect of the elasticity of the degree of the price pass-through. The full impact was reached in the third quarter and was around 0.023 (or 2.3%), thus suggesting a 0.451 dynamic elasticity of the degree of the price pass-through. As in the case of Kenya, it eventually slowed down, but persisted in the long term. The central bank reacted by also tightening the monetary policy (with a peak impact of this in the sixth quarter). It also later relaxed the policy following a corresponding relaxation in inflation, exactly as in the case of Kenya. Similarly, the quarterly growth rate of the real GDP reacted to the exchange rate shock by declining as well.

In summary, the impulse response functions indicate that the extent of the exchange rate pass-through to prices in Cameroon and Kenya over the study period was high, persistent, and incomplete. In comparison, the impulse response functions show slightly lower levels of transmission for the exchange rate shocks (because of the compensatory reaction effect mentioned earlier) than the estimations of the degree of the price pass-through in the medium term (one year) in single-equation models. Moreover, the study's findings of elasticity estimations of 0.3125 for Kenya and 0.451 for Cameroon are consistent with those made by Choudhri and Hakura (2006), who found the elasticity for the price pass-through to be 0.39 for Kenya and Cameroon and 0.46 for Zambia. Kiptui et al (2005) found that the extent of the price pass-through in Kenya was incomplete and disappeared after four quarters, with the exchange rate accounting for 46% of the inflation fluctuations. Other comparable studies on developing countries are Sanusi (2010) and Bwire et al (2013). The former found an elasticity of 0.79 for Ghana while the latter found an elasticity of the pass-through to prices of 0.48 for Uganda. As discussed previously, variance decompositions can be used to understand the relative contribution of structural shocks to the explanation of inflation volatility.

Variance decomposition

In Kenya, variance decomposition revealed that the exchange rate shocks had a modest contribution to inflation volatility, and that inflation was mainly caused by its own shocks, especially in the short term. Specifically, the volatility due to the exchange rate shocks represented 21% to 13% (from one to 10 quarters, respectively - Table 5), while that due to the inflation's own shocks represented about 71% to 26% over the same period, suggesting, as in Choudhri and Hakura (2006, that the level of inflation determined its volatility.

In the case of Cameroon, exactly the opposite results were found: variance decomposition revealed that the exchange rate shocks had an important contribution to inflation volatility. Specifically, they represented 65% to 49% (from one to 10 quarters, respectively- Table 6), while the inflation's own shocks represented about 19% to 5% over the same horizon.

Table 5: Variance decomposition in the case of Kenya

Period	S.E.	Price of oil	GDP per person employed	Money supply	Nominal effective exchange rate	Consumer Price Index
1	0.024	1.314	0.003	5.437	21.943	71.302
2	0.034	0.651	1.992	3.898	29.353	64.105
3	0.039	4.946	2.496	3.000	34.840	54.718
4	0.046	12.474	2.584	3.245	35.137	46.561
5	0.052	17.564	2.022	6.424	30.212	43.777
6	0.057	21.436	1.777	8.625	25.505	42.656
7	0.060	24.941	2.153	10.561	22.774	39.570
8	0.066	26.590	4.874	15.067	19.434	34.034
9	0.073	24.800	7.340	22.096	16.141	29.623
10	0.080	22.621	8.970	28.336	13.582	26.490

Source: Author's compilation

Table 6: Variance decomposition in the case of Cameroon

Period	S.E.	Price of oil	GDP per person employed	Money supply	Nominal effective exchange rate	Consumer price index
1	0.019	10.636	3.091	0.892	65.843	19.538
2	0.031	13.797	3.943	0.355	68.815	13.189
3	0.042	17.557	4.313	0.245	67.726	10.158
4	0.051	23.798	5.460	0.693	62.113	7.935
5	0.055	26.923	7.187	0.957	58.276	6.657
6	0.059	28.878	8.483	0.958	55.756	5.926
7	0.060	30.124	9.580	1.002	53.705	5.589
8	0.061	30.642	10.190	1.089	52.629	5.449
9	0.063	31.562	10.645	1.147	51.144	5.501
10	0.064	32.257	11.354	1.156	49.601	5.631

Source: Author's compilation

6. Conclusion and policy recommendations

The study has tested simple-equation models and models of systems of equations to estimate the extent of the exchange rate pass-through to domestic prices in Cameroon and Kenya for periods that are relevant for policy making, namely one year and below, and beyond (i.e. the long term).

In the case of Kenya, the results of the simple-equation models showed that for the short term, the degree of the exchange rate pass-through to prices varied from -0.14 to -0.22 depending on the model. For a period of over one year (i.e. the medium term), it varied between -0.18 and -0.58 depending on the model, while for the long term it was 1.06. In the case of Cameroon, for the short term the exchange rate pass-through to prices was 0.29 except in the case of the Campa and Goldberg specification. For the medium term (one year), it varied between 0.54 and 0.87. For the long term, it was equal to 0.28. Most of these models have passed the usual diagnostic tests, which is an indication of the robustness of the study's results. These are consistent with those reported in the literature on exchange rate regimes for the short and the medium term, but not for the long term. While they are consistent with those reported in the literature on inflation in the long term, they are not with those in the short term and the medium term.

Regarding models of systems, the study used a triangulation of well specified VECM and SVAR models. The results of these types of models showed that the price of oil, the real GDP growth rate, money supply, the exchange rate, and the Consumer Price Index formed a long term stationary relationship in Kenya and Cameroon. Analysis of the impulse response functions showed a 0.23 immediate impact of the elasticity of the degree of the exchange rate pass-through to prices and a 0.3125 dynamic elasticity of the same degree in the case of Kenya. In that of Cameroon, the immediate effect of the elasticity of the same pass-through was 0.314, while the dynamic elasticity was 0.451. In addition, in the case of Kenya, variance decomposition revealed that exchange rate shocks had a modest contribution to inflation volatility, and that inflation was mainly caused by its own shocks, especially in the short term. In contrast, the contribution of the exchange rate shocks was found to be important in the case of Cameroon. It was also noted that the temporary unexpected depreciation of the exchange rate was followed by a tightening of monetary policy (with a peak impact in the second quarter for Kenyan and in the third quarter for Cameroon). Once again, these results are consistent with those already reported in the literature.

The difference between the results obtained from the single-equation models and the models of systems can be explained by the fact that using these latter enables us to incorporate reaction effects from endogenous exchange rates, in particular the monetary policy reaction, which reduces the magnitude of the initial shock. The study's results are consistent with, though more robust than, those reported in the existing literature. This superiority is attributed to the quality of the specifications of the study's models, which corrected the specification errors that are characteristic of the other studies on Africa.

In conclusion, the dynamic elasticity of the exchange rate pass-through and, therefore, inflation, was found to be persistent in Kenya and Cameroon. This suggests that exchange rate movements are a potentially important source of inflation in the two countries. The policy implication is that monetary authorities need to be vigilant vis-à-vis the exchange rate fluctuations to take rapid monetary policy measures and to place emphasis on foreign exchange interventions capable of curbing the inflationary pressure coming from outside. In addition, it is important that policy makers in the two countries accelerate the pace of structural reforms aimed at economic diversification. The degree of the exchange rate pass-through to inflation, which is still high in the two countries' economies, appears to stem from a less diversified economic structure and, therefore, from increased dependence on imports. Policy makers in the two countries therefore need to create an environment conducive to economic diversification and promotion of domestic industries.

Notes

1. Globalization can affect domestic prices, which are the ultimate goal of monetary policy, in four ways: (1) cheap imports of raw materials and capital goods and enhanced competition; (2) labour mobility and low labour costs; (3) capital movements; and (4) exchange rates.

2. This is notably the case of Kenya, whose currency has been floating since the early 1990s, and whose reforms aimed at facilitating the movement of capital have increased in the recent years.

3. To the author's knowledge, few studies have measured the effect of import prices expressed in foreign currency. Among those that have are Mihaljek and Klau (2001; 2008).

4. The degree of pass-through establishes a link between the exchange rate fluctuations and those of domestic prices. In other words, it refers to the entrepreneurs' ability to adjust their prices as a result of the exchange rate fluctuations.

5. The exchange rate can serve as a tool for correcting internal and external imbalances and one for improving the efficiency in resource allocation and in the stabilization process.

6. An increase in food prices followed by riots against the high cost of living.

7. The inflation rate in the country is usually higher than that desired by the central bank.

8. The extent of the exchange rate pass-through to prices is low for certain countries and high for others.

9. The producer currency pricing (PCP) refers to a situation where prices of imported goods are fixed in the foreign currency and sold to consumers in the local currency of the importing country at the exchange rate on the market. This means that any exchange rate fluctuation will be completely passed on to the domestic prices.

10. This PTM occurs when the exporting firm sets the price of its merchandise, which it sells on several markets in the currency of the destination, importing country. The consequence of this is that the price on the destination market does not always reflect

the fluctuations in the exchange rate.

11. This LCP occurs when the exporting firm sets the price of its merchandise, which it sells on a market in the importing country's currency. The consequence of this is that the price on the destination market does not always reflect the fluctuations in the exchange rate. The effect is thus the same as in the previous case.

12. To the best of the author's knowledge, there is no study that has been done exclusively on Cameroon.

13. All the data are for the year 2014 except for the rural population data, which are for 2015.

14. Both countries underwent structural adjustment programmes and, in 2016, they signed interim Economic Partnership Agreements (EPAs) with the European Union.

15. The biggest change in the trade policy regime, as indicated by Were et al (2002), took place in May 1993 when the requirements for issuing trade licenses were abolished and the exchange rate was allowed to float.

16. Usually, simpler versions are used in the empirical literature; that is, versions omitting the controls for domestic costs and commodity prices, and sometimes also the demand controls. Sometimes a temporal trend is also included to account for the long term trends in, for example, global trade openness or productivity levels. Then, an intercept term appears in a differentiated form of Equation 1.

17. BRUEGEL (Brussels European and Global Economic Laboratory) is a European think-tank specialized in economics.

18. In this study, monthly data have been turned into quarterly ones so that the values obtained correspond to the real dynamics of the exchange rate.

19. The choice of this variable was guided by Aron et al (2014b), in the face of lack of data on the cost of labour, the producer price index, and the industry nominal wage rate.

20. Indeed, inflation and factor productivity (especially regarding labour) are key drivers of the long term wage fluctuations. It should be noted that these countries have experienced a slowdown in total factor productivity due to a slower growth in investment in the aftermath of the 2010 global financial crisis (Adler and Duval, 2017).

21. For either country, the stationary series in levels is included as it is in the econometric estimation.

22. Incorporating previous lags would mean that the price pass-through over four quarters should be computed using methods other than the dynamic simulation.

23. This type of model enables us to regress together stationary series in levels (I [0]) and in first differences (I [1]) if they are cointegrated.

24. That includes the strict heterogeneity of foreign producer prices and staple commodity prices, the long term homogeneity of currency conversion, and is adequate for identifying impulse response functions.

25. That is why they are not presented here, but they are available on demand.

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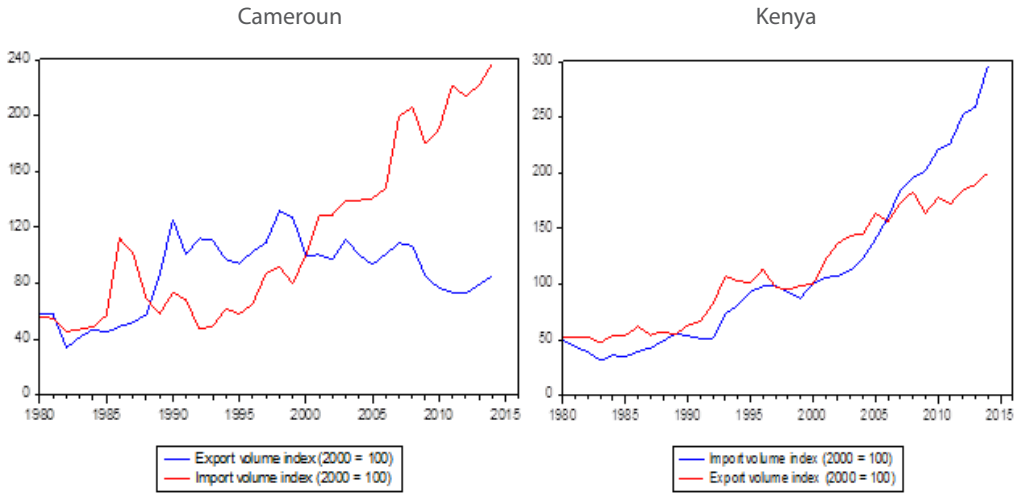
Annexes

Table A.1: Volumes of exports and imports in Cameroon and Kenya



Source: World Bank (2016), World Development Indicators

Table A.2: Results of the stationarity test for the series used in the study

	Cameroon							
	ADF level	PP level	KPSS level	BPURT level	ADF first difference	PP first difference	KPSS first difference	BPURT first difference
P	-2.58	-2.44	0.28	-4.29	-8.53**	-8.57**	0.06**	-10.99**
e	-1.87	-2.11	0.16	-16.06*	-10.54**	-10.54**	0.05**	
w^x	-2.91	-2.88	0.12	-8.25**	-4.1**	-12.94**	0.07**	
$pcom^x$	-2.25	-1.81	0.25	-3.63	-2.67/-6.81**	-5.28**	0.10**	-4.44/-8.01**
w^m	-3.68**	-3.63**	0.08**					
y^x	-3.08	-2.25	0.16	-5.73**	-5.09**	-5.09**	0.04**	
Y^m	-2.34	-4.42**	0.16		-3.99**	-5.76**	0.13**	
M2	-8.47**	-8.61**	0.03**	-9.35**				

BPURT: Break Point Unit Root Test; ** significant at 5%

	Kenya							
	ADF level	PP level	KPSS level	BPURT level	ADF first difference	PP first difference	KPSS first difference	BPURT first difference
P	-1.52	-1.18	0.07	-5.06	-4.59**	-7.96**		-9.39**
e								
w^x	-1.68	-1.3	0.32	-6.72**	-8.58**	-8.13**	0.05**	
$pcom^x$	-6.21**	-6.11**	0.07**	-11.87*				
w^m	-1.48	-1.62	0.15	-2.87	-1.12/-7.23**	-4.26**	0.12**	-3.79/-8.09**
y^x	-1.22	-2.82	0.26	-4.57	-3.01/-5.66**	-4.53**	0.08**	-4.39/-6.67**
Y^m	-3.08	-2.25	0.16	-5.73**	-5.09**	-5.09**	0. 044**	
M2	-2.54	-2.64	0.18	-4.08	-3.83**	-6.07**	0.03**	
M2	-2.33	-1.87	0.33	-5.96**				

BPURT: Break Point Unit Root Test; ** significant at 5%

Table A.3: Technical details about the structural VAR (Bwire et al., 2013)

One of the major shortcomings of the unrestricted VAR (UVAR) approach is the difficulty in interpreting impulse responses based on it. This is because the choice of the Cholesky decomposition in UVAR is not unique, given the number of alternative sets of orthogonalized impulse responses that can be obtained from any estimated VAR model. Sims (1980) sought to overcome this difficulty by choosing a type of orthogonalization that typically imposes a causal order on the VAR. But this has not been fully accepted in the literature. In the absence of such restrictions, the orthogonalized impulse responses are difficult to interpret, such that the estimated model gives few significant insights into the economic system it represents. The SVAR approach builds on Sims' approach but attempts to identify the impulse responses by automatically imposing restrictions on the covariance matrix of structural errors and/or the long term impulse responses themselves. SVAR allows contemporaneous relationships between the elements of a vector of endogenous variables. This makes it possible to model the dynamic and contemporaneous endogeneity between variables. In a matrix form based on Hamilton (1994), SVAR can be written as follows:

$$\beta_0 x_t = k + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \ldots + \beta_p x_{t-p} + \mu_t \quad (1)$$

Where x_t is an endogenous variable and μ_t the white noise error. A white noise error means that the structural disturbances are not correlated, such that $E \mid \mu_t \mu_t' \mid = D$, where D is a diagonal matrix. Pre-multiplying equation (1) by β_0^{-1} gives us the reduced (VAR) form of the structural dynamic model:

$$x_t = \beta_0^{-1}\left(k + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \ldots + \beta_p x_{t-p} + \mu_t\right)$$

$$x_t = c + \varphi_1 x_{t-1} + \varphi_2 x_{t-2} + \cdots + \varphi_p x_{t-p} + \varepsilon_t \quad (2)$$

Where $\varphi_s = \beta_0^{-1}\beta_s$, (s=1,2,…... p), $c = \beta_0^{-1}k$ and $\varepsilon_t = \beta_0^{-1}\mu_t$, the variance-covariance matrix is given by:

$$E \mid \varepsilon_t \varepsilon_t' \mid = \beta_0^{-1} E \mid \mu_t \mu_t' \mid (\beta_0^{-1})' = \Omega$$

To generate structural shocks, the study will use a Cholesky decomposition of the variance-covariance matrix of the residues of the VAR in its reduced form Ω. Since the estimation of the SVAR model has k^2 more parameters than the VAR one, to find a single solution requires that both the order condition and the rank condition be satisfied at the same time. The order condition requires the number of parameters in the β_0 and D to be smaller than the number of free parameters in the Ω matrix. Since Ω is a symmetrical matrix, the number of free parameters in the Ω matrix is defined by k*(k+1)/2, where k is the number of endogenous variables included in the system.

Assuming that D is a diagonal matrix, then β_0 cannot have more free parameters than k(k-1)/2. Two different restrictions can be imposed on the β_0 matrix. The first is the normalization restriction which aims to assign the value 1 to the variables $x_{t,i}$ in each of the i^{th} equations. The second is the exclusion restriction which aims to assign 0 to certain variables of the equation (especially contemporaneous relationships). These restrictions are defined by the theoretical model.

The rank condition for the identification of a structural VAR is more complex. It requires the columns of the J matrix to be linearly independent, which Hamilton (1994) defines as follows:

$$J = [\frac{\partial vech(\Omega)}{\partial \theta_B^{'}} \frac{\partial vech(\Omega)}{\partial \theta_D^{'}}$$

The vech ( ) operator selects the distinct element Ω, rendering the state sufficient for local identification. By imposing the constraints suggested by the theoretical model, we construct the B_0 matrix and we find the relationship between the error terms of the reduced form and the structural perturbations:

$$\varepsilon_t = \beta_0^{-1}\mu_t$$

$$\begin{bmatrix} \varepsilon_t^{pcom\,x} \\ \varepsilon_t^{y^m} \\ \varepsilon_t^{m} \\ \varepsilon_t^{e} \\ \varepsilon_t^{cpi} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^{pcom\,x} \\ u_t^{y^m} \\ u_t^{m} \\ u_t^{e} \\ u_t^{cpi} \end{bmatrix} \quad (4)$$

where $u_t^{pcom\,x}$ designates the oil price shock (supply); $u_t^{y^m}$ the real-GDP growth-rate shock (demand); u_t^m the monetary shock; u_t^e the nominal exchange rate shock (external); and u_t^{cpi} the inflation rate shock. Therefore, according to our theoretical model, the B matrix has 10 free parameters to be estimated, which are the same as those needed for the order condition to be satisfied.

This recursive identification model is based on Ito and Sato (2007), Hahn (2003), and McCarthy (2000). It suggests that the identified shocks simultaneously affect their corresponding variables and those that are ordered later, without affecting those already ordered. In the B matrix resulting in the system in (4), it is reasonable to first order the most exogenous variables. The pump price of crude oil is exogenous to the national economy; therefore, oil shocks are modelled independently of the shocks to the other variables in the system. The set-up in (4) means that there is a set of four restrictions, since the restriction imposes zero on the 2nd, the 3rd, the 4th, and the 5th element in its first row. In the second row, there are three additional restrictions based on the assumption that real GDP growth rate shocks are influenced by shocks to the pump price of crude oil and are independent of the shocks to all other variables in the system. This means that money supply, exchange rate, and inflation rate are assumed to have no contemporaneous effect on real GDP growth rate. This amounts to imposing zero restrictions on the 3rd, the 4th, and the 5th elements in the second row of the matrix. The money supply shocks are assumed to be influenced by the shocks caused by pump price of crude oil and the shocks to real GDP growth rate.

It is assumed that the exchange rate and inflation rate do not have any contemporaneous effect on money supply. This assumption adds two more restrictions and amounts to imposing zero restrictions on the 4th and the 5th elements in the third row of the matrix. It is also assumed that the exchange rate shocks are influenced by the shocks caused by crude oil prices, those caused by real GDP growth rate, and those caused by money supply. This latter assumption implies that inflation has no contemporaneous effect on the exchange rate, which in turn constitutes the 10th restriction and thus meets the minimum requirement for the order condition to be satisfied. Finally, the shocks to domestic inflation are ordered last because they are supposed to be influenced by the shocks to all the variables in the model.

Under this structure, the model is estimated as a SVAR one using a Cholesky decomposition. The impulse response from the CPI inflation to the orthogonalized shocks caused by the exchange rate movements thus provides estimations of the effect of the exchange rate on domestic inflation. In addition, a decomposition of the inflation fluctuations by the CPI allows us to determine the significance of each of the variables in the system to domestic price fluctuations.

Table A.4: Summary tables of the diagnostic tests on the different models estimated

Kenya					
Column	1	2	3	4	5
Model	Differentiated equation without a lagged dependent variable	Differentiated equation with a lagged dependent variable	Campa and Goldberg specification	Equilibrium-correction model: error correction term at t-4	ARDL with automatic selection
Equation No.	3	3	4	6	6
Jargue-Bera Normality	0.00	0.00	0.00	0. 00	0.002
Breusch-Godfrey Serial Correlation LM (2 lags)	0.155	0.99	0.008	0. 22	0.094
Breusch-Pagan-Godfrey Heteroskedasticity	0.99	0.99	0.90	0.99	0.87
Ramsey Reset	0.42	0.39	0.002	0.28	0.084

Source: Author's compilation. The values in the table are p-values.

Cameroon					
Column	1	2	3	4	5
Model	Differentiated equation without a lagged dependent variable	Differentiated equation with a lagged dependent variable	Campa and Goldberg specification	Equilibrium-correction model: error correction term at t-4	ARDL with automatic selection
Equation No.	3	3	4	6	6
Jargue-Bera Normality	0.2	0.18	0.00	0.71	0.9
Breusch-Godfrey Serial Correlation LM (2 lags)	0.38	0.51	0.057	0.45	0.12
Breusch-Pagan-Godfrey Heteroskedasticity	0.74	0.42	0.84	0.9	0.91
Ramsey Reset	0.64	0.7	0.03	0.51	0.32

Source: Author's compilation. The values in the table are p-values.

Bounds tests:

For the case of Cameroon

ARDL Bounds Test
Date: 12/04/16 Time: 02:43
Sample: 1991Q1 2013Q1
Included observations: 88
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	12.11226	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	1.99	2.94
5%	2.27	3.28
2.5%	2.55	3.61
1%	2.88	3.99

For the case of Kenya

ARDL Bounds Test
Date: 11/11/16 Time: 06:03
Sample: 1991Q3 2013Q1
Included observations: 87
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	4.910359	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.33	3.25
5%	2.63	3.62
2.5%	2.9	3.94
1%	3.27	4.39

Table A.5: Johansen cointegration test using the EViews software

For the case of Cameroon

Unrestricted cointegration rank test (trace)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.311	100.716	69.819	0.000
At most 1*	0.267	66.045	47.856	0.000
At most 2*	0.233	37.188	29.797	0.005
At most 3	0.117	12.563	15.495	0.131
At most 4	0.010	0.968	3.841	0.325

The trace tests indicate 3 cointegrating eqn(s) at the 0.05 level.

Unrestricted cointegration rank test (Maximum Eigenvalue)

hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.311	34.671	33.876	0.000
At most 1*	0.267	28.857	27.584	0.034
At most 2*	0.233	24.625	21.132	0.015
At most 3	0.117	11.595	14.265	0.127
At most 4	0.010	0.968	3.841	0.325

The max-eigenvalue test indicates 3 cointegrating equation(s) at the 0.05 level.

For the case of Kenya

Unrestricted cointegration rank test (trace)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.498	131.525	69.819	0.000
At most 1*	0.346	67.462	47.856	0.000
At most 2	0.212	27.932	29.797	0.080
At most 3	0.054	5.814	15.495	0.717
At most 4	0.007	0.624	3.841	0.429

The trace tests indicate indicate 2 cointegrating equation(s) at the 0.05 level.

Unrestricted cointegration rank test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.498	64.063	33.876	0.000
At most 1*	0.346	39.530	27.584	0.000
At most 2*	0.212	22.118	21.132	0.036
At most 3	0.054	5.190	14.265	0.717
At most 4	0.007	0.624	3.841	0.429

The max-eigenvalue test indicates 3 cointegrating equation(s) at the 0.05 level.

Mission

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