Determinants of Inflation in a Dollarized Economy: The Case of Zimbabwe

Philton Makena

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Determinants of Inflation in a Dollarized Economy: The Case of Zimbabwe

By

Philton Makena
Reserve Bank of Zimbabwe

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Abstract

Adverse inflationary pressure has been a persistent feature of the Zimbabwean economy under a dollarized regime, which was adopted in January 2009. Since the beginning of 2012, the country's annual inflation has been on a downward trend, initially exhibiting characteristics of disinflation and subsequently deflation. This paper seeks to shed some light on the determinants of inflation in Zimbabwe under dollarization. The study applies a single error correction model (ECM) to investigate possible short and long-run determinants of Zimbabwe's overall, food and non-tradables' consumer price indices (CPIs) for the period January 2010 to December 2015. The main findings are that the country's long-run price level is influenced by changes to the South African Rand/US Dollar exchange rate and South African inflation given the high trade linkages between the two countries, mainly dominated by Zimbabwe's imports of raw materials, and intermediate and consumer goods from that country. On the other hand, domestic fuel price movements have an impact on the country's price level as it imports all its fuel. In order to avert a deflationary spiral, authorities need to mobilize significant domestic public, private-sector and international funding in order to increase the capital stock, refurbish the existing infrastructure and invest in new infrastructure projects in order to increase the country's potential output. These measures will shore up both economic growth,These measures will shore up both economic growth, employment and, ultimately, price stability.

1. Introduction

Zimbabwe's road to hyperinflation and the eventual adoption of a multi-currency system, henceforth referred to as dollarization, in February 2009, is well documented (Hanke, 2008, Makochekanwa, 2009, Hanke and Kwok, 2009, Kramarenko et al., 2010). For over a decade and before the adoption of dollarization, the country's year-on-year inflation, as measured by the consumer price index (CPI), persistently increased. During that time, the economy experienced high levels of money supply growth and distorted prices and acute foreign currency shortages proliferated, in part, by speculation in a number of economic sectors. These developments gave rise to high inflation and, consequently, declining gross domestic product (GDP) as well as the deterioration of the country's balance of payments (BOP) position. In March 2007, price increases reached hyperinflation levels, defined as a rate of inflation per month that exceeds 50 per cent. The year-on-year inflation peaked at 231.0 million per cent in July 2008.

Zimbabwe adopted dollarization in a bid to manage hyperinflation and a threatening economic crisis. Dollarization allowed for the simultaneous use of five currencies, namely the United States Dollar, South African Rand, British Pound, Botswana Pula and the Euro. The Zimbabwe Dollar was subsequently officially demonetized in June 2015. Dollarization brought about economic stability, particularly during the second half of 2009. The country's real GDP growth increased from 5.7% in 2009, albeit from a low base, to 10.6% in 2011, before moderating to an estimated 1.2% in 2015. The recovery was largely due to improved policies, a favourable external environment and stability brought about by dollarization.

After the adoption of dollarization, adverse inflationary pressures have remained subdued. Since the beginning of 2012, Zimbabwe's annual inflation has been on a downward trend, initially exhibiting characteristics of disinflation and, subsequently, deflation.[1] This phenomenon has raised questions among policymakers and in academia about the source(s) of this sustained decline in inflation. Insofar as the domestic inflation rate can also be influenced by domestic monetary policy decisions, the adoption of dollarization in Zimbabwe implied that monetary policy instruments, especially money supply and interest rate decisions, were effectively taken out of the hands of the authorities. As such, there are virtually no tools at the disposal of the central bank to mitigate the effects of both domestic and foreign influences on domestic inflation. This makes an interesting case to investigate the dynamics of inflation in Zimbabwe under dollarization.

External influences in the form of changes in crude oil prices, the South African Rand/US Dollar exchange rate and the CPI for South Africa are being viewed as the main factors currently explaining inflation dynamics in Zimbabwe. There has been growing concern over the impact of macroeconomic developments in South Africa on Zimbabwe's price level, coupled with declining international energy prices. Whilst these developments have enjoyed widespread domestic media exposure and debate, there is a scarcity of empirical literature, save for Kavila and Le Roux (2016), who assess the possible impact of such factors on Zimbabwe's inflation. This study seeks to fill this gap by adding to the literature on inflation in Zimbabwe and improving upon past studies by decomposing inflation into overall, food and non-food tradables and extending the research period to December 2015, to cover the period of deflation. The study is also motivated by the scarcity of studies on inflation in dollarized economies.

The study seeks to answer the following main questions: Do changes to international crude oil prices (proxied by domestic fuel prices), the South African Rand/US Dollar exchange rate and the South African CPI have short and long-run implications for Zimbabwe's inflation under a dollarized regime? What are the possible causes of deflation in Zimbabwe? The period covered in this study is January 2010 to December 2015. This period coincides with an era when the country was under full dollarization and experienced episodes of disinflation and deflation. While a price correction was experienced during the first twelve months after the adoption of dollarization, this study excludes that period in order to focus on fundamental short and long-term determinants of inflation in Zimbabwe.

To answer the research questions, the study follows two empirical steps. First, guided by a general framework for the long-term behaviour of the overall price level, the study tests for and finds cointegration vectors for the three general models for the overall, food and non-food tradables CPI sub-categories for the period 2010:1 to 2015:12 using the Johansen maximum likelihood procedure (Johansen, 1988). Few studies have gone beyond analyzing inflation dynamics by decomposing the components of CPI into overall, food and non-food tradables. In a study to establish the importance of factors that contributed to CPI inflation in Ethiopia, Durevall et al. (2013) identify cereal, food and non-food prices as key components of CPI inflation in that country. Second, the three error correction models (ECMs) are included in the respective three general ECMs for overall, food and non-food tradables CPI, whose stochastic properties are then investigated. Third, the general models are reduced to empirically constant parsimonious models using a general-to-specific modelling strategy.

The main findings are that Zimbabwe's long-run price level is influenced by changes to the South African Rand/US Dollar exchange rate and South African inflation given the high trade linkages between the two countries, mainly dominated by Zimbabwe's imports of raw materials and intermediate and consumer goods from that country. On the other hand, domestic fuel price (as a proxy for crude oil prices) movements have an impact on the country's price level as it imports all of its fuel. Changes to these three external variables have long-run effects on Zimbabwe's price level under a dollarized regime. In the short run, changes to the overall domestic CPI are influenced by movements in domestic overall CPI and fuel. The short-run variations in Zimbabwe's food price level are explained by changes in domestic food prices and world grain prices. In the short run, non-food tradables' prices are determined by past domestic and South African non-food tradables' prices and the level of domestic economic activity.

The rest of the paper is organized as follows: Chapter 2 details how Zimbabwe's CPI is measured, its major components and how it evolved under dollarization. Chapter 3 reviews the theoretical and empirical literature on the relationship between dollarization and inflation. Chapter 4 explains the econometric methodology, data sets, variables and data sources while Chapter 5 presents and discusses the empirical results. Chapter 6 concludes.

2. Headline, food and non-food prices in Zimbabwe: Measurement and proximate causes

The CPI is defined as a measure of the evolvement of the average price level of a representative basket of consumer goods and services purchased between two periods, typically a month, a quarter or a year. In calculating Zimbabwe's CPI, the Zimbabwe National Statistics Agency (ZIMSTAT) adopted a new classification in January 2013, the individual consumption by purpose (COICOP), in accordance with international guidelines.[2] Prices of all items in the CPI basket are observed and recorded in United States Dollars, given the dollarized regime.

The country's major CPI groups, by weight, are food and non-alcoholic beverages (33.5%), housing, water, electricity, gas and other fuels (17.7%), furniture, household equipment and maintenance (9.9%) and transport (9.8%), as shown in Table 1.

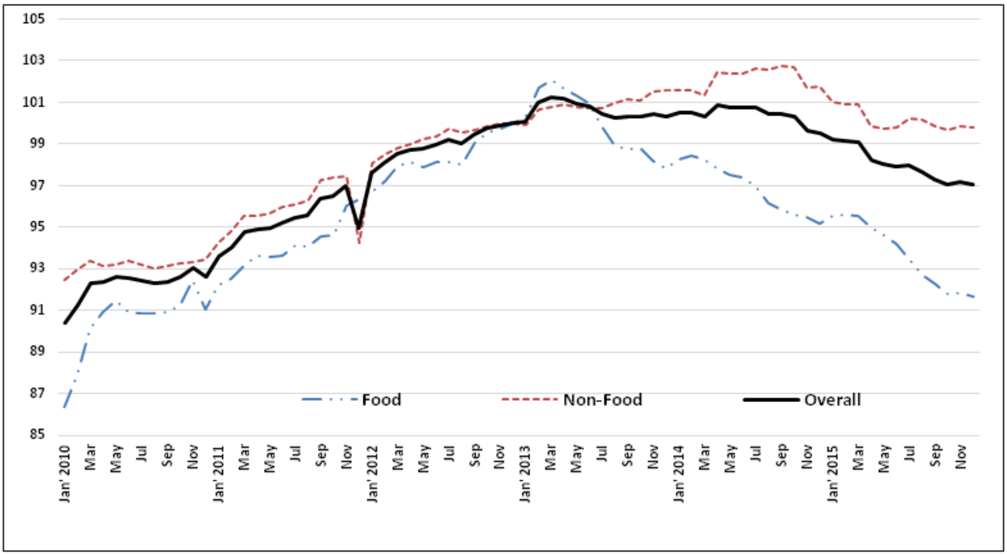
Table 1: Major groups in the consumer price index by 2012 weights

No.	Group	Weight (%)
1	Food and non-alcoholic beverages	33.5
2	Housing, water, electricity, gas and other fuels	17.7
3	Furniture and equipment	9.9
4	Transport	9.8
5	Clothing and footwear	6.0
6	Education	5.7
7	Alcoholic beverages and tobacco	4.4
8	Miscellaneous goods and services	3.9
9	Communication	3.4
10	Health	2.2
11	Recreation and culture	2.1
12	Restaurants and hotels	1.4
	Total	100.0

Source: Zimbabwe National Statistics Agency (ZIMSTAT).

Food and non-food CPI weights are 33.5% and 66.5%, respectively. Figure 1 depicts the trend in food, non-food and overall prices for Zimbabwe. Food and non-food price fluctuations are important in explaining the country's overall CPI.

Figure 1: Zimbabwe's overall, food and non-food consumer price indices: January 2010 – December 2015



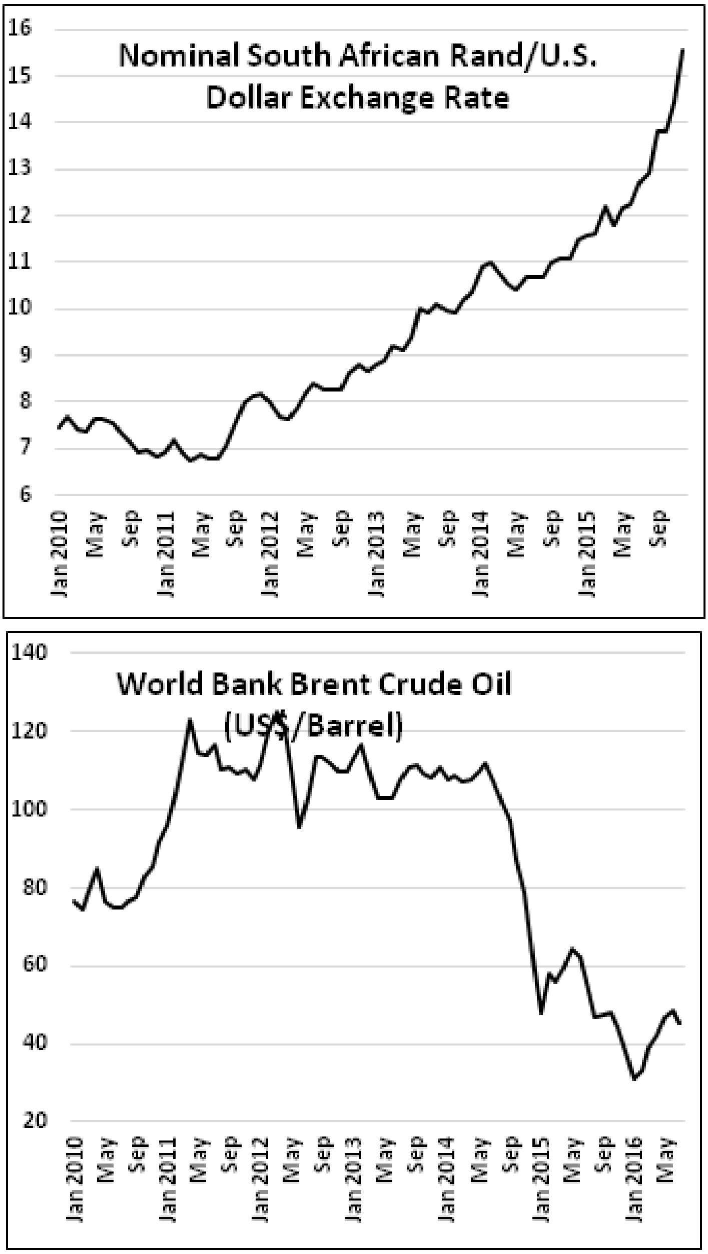
Source: Zimbabwe National Statistics Agency (ZIMSTAT).

As shown in Figure 1, food prices have been more volatile than non-food prices and have played a significant role in generating the current deflationary episode in Zimbabwe. Local food prices in Zimbabwe are typically affected by both domestic and external factors. Domestic influences on the price level include the level of aggregate demand, fuel costs, size of staple cereals (maize, rice and wheat), harvests and other supply and cost factors. In particular, the country's maize harvests in 2012 and 2013 comprised about 54 per cent and 44 per cent of national requirements, respectively. This partly explains the increase in food prices between 2012 and 2013. In 2014, the country's maize harvest improved to 80 per cent of the national requirement; a development that partly explains the deflationary trend after 2013. In addition, low levels of aggregate demand and lower fuel costs are contributing to falling food prices. On the other hand, prices of non-food tradables, whose CPI weight is about 57.7 per cent, are mainly influenced by external factors.[3] These include international demand or supply conditions, exchange rate movements, particularly the South African Rand/US Dollar exchange rate, as well as price fluctuations in South Africa, which is Zimbabwe's major trading partner.

The CPI inflation rate in Zimbabwe has, in recent years, been highly associated with the CPI inflation in South Africa, mostly due to the high share of imports from South Africa. According to ZIMSTAT's annual reports for the period 2009–2015, Zimbabwe's merchandise imports from South Africa, as a share of the country's total merchandise imports, averaged 55.4%, followed by the EU at 8.1% and the United Kingdom at 4.8%. The country's imports of consumer goods, mainly from South Africa, remain high under dollarization given that capacity utilization for the domestic manufacturing sector, at 57.2% in 2011 and 34.3% in 2015, remains well below the pre-crisis average of 80.0%. As such, a rise in South African prices, ceteris paribus, is expected to cause prices in Zimbabwe to rise while the opposite would be true in the case of a decline in South African prices.

In addition, the US dollar, which is Zimbabwe's main trading currency, has been strengthening against the South African Rand, as shown in Figure 2.

Figure 2: South African Rand/US Dollar exchange rate and Brent crude oil prices: 2010–15



Source: South African Reserve Bank and World Bank.

Movements in the South African Rand/US Dollar exchange rate have potentially important implications for Zimbabwe's price level given the trade linkages between Zimbabwe and South Africa. Specifically, the sustained depreciation of the South African Rand against the US Dollar in nominal terms has, to some extent, suppressed the price level in Zimbabwe. Depreciation of the South African Rand potentially makes it relatively cheaper for Zimbabwean companies and consumers to buy raw materials, consumption and intermediate goods from South Africa. As such, prices in Zimbabwe would generally be expected to fluctuate according to import costs of mainly South African goods. Domestic inflationary pressures are expected to ease when the South African Rand depreciates against the US Dollar, while the opposite would be true following an appreciation.

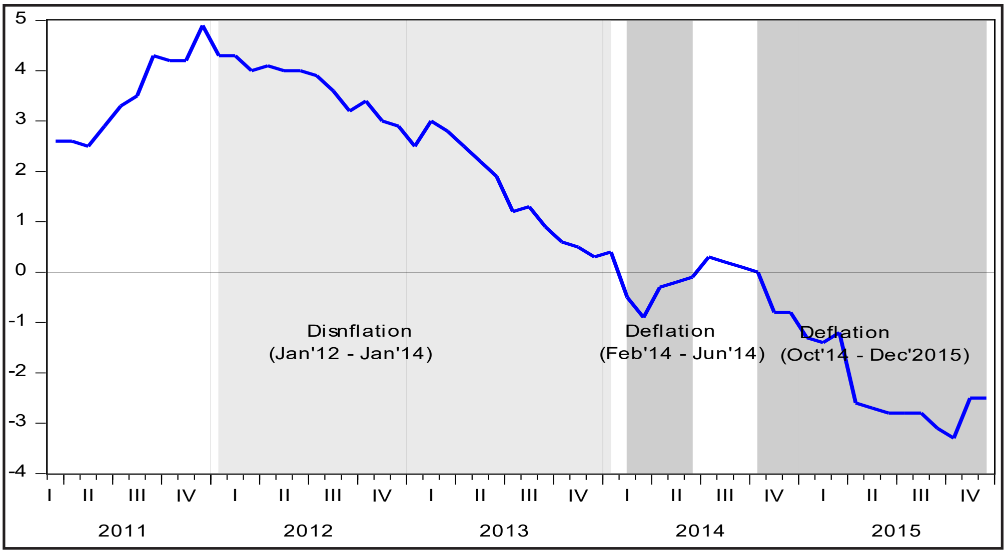
International Brent crude oil prices declined from slightly above US$125 per barrel in April 2011 to below US$60 per barrel by the end of 2014, and hovered around US$60 per barrel during the first half of 2015 before ending the year below US$40/barrel (see Figure 2). This development has, to a certain degree, brought benefits to non-oil producing economies dependent on petroleum imports, such as Zimbabwe. The impact of the sustained slump in international oil prices has been evidenced by declines in retail fuel prices in Zimbabwe, a development that potentially exerts downward pressure on the country's price level. To that extent, this study considers movements in domestic fuel prices as potentially having short and long-run implications for inflation dynamics in Zimbabwe.

On the domestic front, economic activity, as proxied by the monthly volume of manufacturing index, declined from 65.1 in 2011 to 54.1 in 2013, before averaging 55.0 between 2014 and 2015.[4] The weakening of the volume of manufacturing index follows a decline in industrial capacity utilization attributed to the influx of cheap imports, lack of long-term capital, antiquated machinery, high domestic production costs and erratic provision of utilities such as water and electricity, as well as the depressed domestic aggregate demand. The continued decline in the level of economic activity has, to some extent, a bearing on the level of domestic prices.

The share of government's employment costs in fiscal revenues has increased significantly after the adoption of dollarization, partly due to the cost of living adjustments awarded to the civil servants and the shrinking of the revenue base. Employment costs increased from 59.5% of revenues in 2011 to 73.4% in 2014 and to 89.9% for the first half of 2015. While such public domestic policies, as well as weather patterns, bank loans, money supply and political events such as the 2013 harmonized national elections, would also have implications on inflation dynamics in Zimbabwe, the focus of this study is to analyze how selected factors, in particular crude oil prices (proxied by domestic fuel prices), the South African Rand/US Dollar exchange rate and the CPI for South Africa, help explain inflation dynamics in Zimbabwe under dollarization.

Since the beginning of 2012, Zimbabwe's annual inflation has been on a downward trend, initially exhibiting characteristics of disinflation and, subsequently, deflation as shown in Figure 3. In essence, the dollarized regime ushered in a radically new environment, with a bearing on the country's inflation dynamics, among other implications.

Figure 3: Zimbabwe's annual inflation profile (%): March 2011 – December 2015



Source: Reserve Bank of Zimbabwe and ZIMSTAT.

This development, as viewed by the various economic agents, emanates from a variety of factors, some of which are discussed in this study. There is, however, no consensus on the factors that influence inflation in Zimbabwe under a dollarized regime. In addition, there is a scarcity of empirical evidence pointing to factors that influence inflation, in particular the deflationary phase that the country is currently experiencing. It is against this background that this study attempts to empirically determine the factors that are influencing inflation in Zimbabwe under dollarization.

3. Theoretical and empirical literature review

Dollarization occurs when residents of a country use foreign currency parallel to or instead of the domestic currency (Hanson 2002). Dollarization can also be defined as entailing the holding, by residents of a country, of a significant share of their assets in the form of foreign currency-denominated assets. The term dollarization is not only applied to usage of the US Dollar, but also generally to the use of any foreign currency as or in place of the national currency. Under full dollarization, a country adopts another country's currency as its legal tender. The adopted currency takes over all functions of the domestic currency, which include being a unit of account, medium of exchange and store of value. The adoption of full dollarization entails that a country gives up any possibility of monetary and exchange rate policies.

There are a number of independent nations that adopted full dollarization and these include Panama, El Salvador, Ecuador and Zimbabwe. Several other countries that adopted dollarization are city-states fully integrated into their neighbours' economies, such as Liechtenstein and Andorra. Other countries and territories operating dollarized monetary regimes include East Timor, Montenegro, Monaco and Kosovo. Furthermore, partial dollarization is prevalent in countries such as Argentina, Cuba, Bolivia, Peru, Vietnam and Turkey. Baliño et al. (1999) argue that the adoption of dollarization in Panama, Ecuador, El Salvador and Croatia enhanced financial integration and stability. The advent of dollarization generally presents a defining moment for an economy's real, monetary, financial and external sectors. Under full dollarization, an economy ultimately benefits from a reduction in inflation, the elimination of inflationary expectations and price stability. In their study to investigate whether dollarized economies exhibited faster growth and lower volatility than economies with a domestic currency, Edwards and Magendzo (2003) concluded that "dollarized countries have had a significantly lower rate of inflation than non-dollarized ones". Empirical analyses by Bogetic (2000) and Eichengreen and Hausmann (1999) also found that dollarized and currency union countries have experienced significantly lower inflation than countries with a domestic currency.

There is plenty of literature that attempts to examine the relationship between inflation and its determinants in general. Notable among this is the debate on whether demand-side factors (resulting from increased economic activity) or supply-side factors (due to increased cost) cause inflation. Hoon and Papi (1997) discuss three approaches to investigating causes of inflation, namely the monetary, public finance and structural and cost-push approaches. Ritzberger-Grünwald (2013) appreciates that domestic inflation is influenced by domestic monetary policy decisions, which in turn are dependent on the institutional environment. There are also a number of studies that have empirically investigated the impact of external shocks on economies' inflation. These include Gelos and Ustyugova (2012), Duma (2008), and Ritzberger-Grünwald (2013). Most of these studies applied vector autoregressive (VAR) models and the Johansen-Juselius cointegration technique that included variables such as money supply, the wage rate, economic growth, commodity prices, exchange rates, weather, oil prices and political events. However, there are limited empirical studies that explore the impact of shocks, internal and external, on inflation in fully dollarized economies. Baliño et al. (1999) postulate that most empirical studies on determinants of inflation do not include nations that have fully dollarized, largely because of data deficiencies that are characteristic of city states or territories, the majority of whom adopted full dollarization.

A study by Gachet et al. (2008) to investigate determinants of inflation in a fully dollarized Ecuador for the period 2004–2008 using a structural VAR approach, found that inflation in the first quarter of 2008 was mainly caused by international commodity prices, exchange rate movements and government spending on wages. The International Monetary Fund (IMF, 2012) established that Zimbabwe's inflation is highly correlated to both the South African CPI and producer price indices inflation rates. This, according to the IMF, occurs with a lag and is largely because of the large share of imports from South Africa. More recently, Kavila and Le Roux (2016) explored the dynamics of inflation in Zimbabwe under dollarization for the period 2009:1 to 2012:12 by employing an autoregressive distributed lag (ARDL). Their findings are that movements in the US Dollar/South African Rand exchange rate, international oil prices and South African inflation rate had both short and long-run impacts on Zimbabwe's inflation.

Theoretical and empirical literature also abounds with the exchange rate pass-through, a measure of the extent to which changes in the exchange rate are reflected in prices of goods and services. Many monetary models of the exchange rate and balance of payments assume a one-to-one relationship between the exchange rate and domestic prices, based on the law of one price and purchasing power parity (PPP). Suffice to say, there is a growing body of research that disputes this assertion, given a variety of factors that can cause the PPP to deviate from its equilibrium, as detailed by Clark and MacDonald (1999).

Burstein and Gopinath (2013) and Gagnon et al. (2014) discuss recent theoretical and empirical developments on the link between prices and exchange rates, focusing on the various issues that connect the two variables. There are three major channels through which effects of exchange rate movements are transmitted to consumer prices. These include (i) prices of imported consumption goods, (ii) domestically produced goods priced in foreign currency and (iii) prices of imported intermediate goods. While there exists extensive theoretical and empirical literature on the relationship between exchange rate and prices, few studies have focused on sub-Saharan Africa

(SSA). Where such studies have been conducted for specific African countries, most results show relatively low exchange rate pass-through and, in some cases results are statistically insignificant.[5]

Methodology

We model the determinants of inflation in Zimbabwe under a dollarized regime by employing error correction models developed through a general to specific modelling technique. The choice of the methodology is motivated by an extension of the purchasing power parity (PPP) theory. First, we discuss the extension of the PPP theory, followed by stationarity and cointegration tests; a specification and estimation of error correction models.

Model specification

The specification of the model to analyze the determinants of inflation in Zimbabwe under dollarization is guided by theory as well as a priori assumptions about the relationship between the chosen variables. Given that the country is currently importing most of its consumption and intermediate goods from South Africa, the country's overall CPI consists of domestic prices (p_d) and foreign prices (p_f). This relationship, an extension of the purchasing power parity (PPP) theory, can be expressed as follows:

$$p = p_d^{\alpha}(Ep_f)^{1-\alpha}\, p = p_d^{\alpha}(Ep_f)^{1-\alpha} \qquad (1)$$

where α is the share of domestic component and EE is the nominal exchange rate. In the case of Zimbabwe, this representation postulates that the country's overall price level is influenced by changes to domestic prices, the South African Rand/US Dollar nominal exchange rate and the CPI for South Africa. Equation 1 above can be expressed in log levels as follows:

$$p = \alpha p_d + (1 - \alpha)(e + p_f)p = \alpha p_d + (1 - \alpha)(e + p_f) \qquad (2)$$

Equation 2 represents a general framework for the long-term behaviour of the overall price level as influenced by movements in both domestic and foreign prices, measured in domestic currency, which is the US Dollar in the case of Zimbabwe. While the quantity theory of money would ideally be considered in analyzing a country's inflation dynamics, the study period is limited to an era when Zimbabwe is fully dollarized, implying that the country's central bank does not have influence over money supply or interest rates.

Stationarity and cointegration tests

The general assumption that domestic fuel prices, the South African Rand/US Dollar exchange rate, and CPIs for both South Africa and Zimbabwe are non-stationary, coupled with the observation that they tend to "move together" over time, implies that there exist some influences on the series that may bind this relationship in the long run. In other words, it can be said that the permanent long-run effect of these seemingly integrated variables would be an outcome of the same structural shock. Engle and Granger (1987) provide a theoretical approach to the concept of cointegration by postulating that although the dependent variable and its determinant(s) may be individually non-stationary, they will tend to move together in the long run, to the extent that a linear combination of them will be stationary. As a result, the data generated by such a model will be cointegrated. This outcome is supported by Granger's Representation Theorem, which states that if the dependent variable and the independent variable(s) are cointegrated, then an error correction model representation generates a cointegrated series (ibid). Zimbabwe's CPI, South African CPI, South African Rand/US Dollar exchange rate, and domestic petroleum prices are expected to be cointegrated given the relationship explained earlier.

In choosing a suitable model for estimating the long-run determinants of inflation in Zimbabwe, it was assumed that changes to the domestic CPI are influenced by movements in South Africa's CPI, the nominal South African Rand/US Dollar exchange rate and domestic fuel prices and that there are most likely no contemporaneous feedback relations among the four variables. The possible indirect impact of changes in the domestic CPI on domestic fuel prices can be through expected future changes of the domestic CPI. As such, tests for weak exogeneity of domestic fuel prices, the South African Rand/US Dollar exchange rate and overall, food and non-food tradables' CPIs for South Africa and Zimbabwe were conducted. As detailed in Johansen (1992), the weak exogeneity statistic tests whether or not the corresponding row of kk is zero. If it is indeed zero, a disequilibrium that may occur in the cointegrating relationship would not feed back into the model dependent variable.

Single equation error correction model

To examine the relative prominence of movements in domestic fuel prices, the South African Rand/US Dollar exchange rate and CPI for South Africa to explain variations in Zimbabwe's CPI, single ECMs for the three domestic price indices, namely overall, food and non-food tradables' CPIs as the dependent variables, were constructed. The ECM approach allows for tests for the existence of cointegration between a dependent variable and its determinants. The choice of model is based on the assumption that the model variables are non-stationary and co-integrated but that domestic fuel prices, the South African Rand/US Dollar exchange rate and CPI for South Africa are individually weakly exogenous, while the CPI for Zimbabwe is not weakly exogenous.

This study analyses three components of the country's CPI combined and separately. Model 1 has overall CPI as the dependent variable, Model 2 has food CPI as the dependent variable, while Model 3 has non-food tradables' CPI as the dependent variable. A representative single equation ECM specification for Zimbabwe's overall CPI is of the form:

$$\begin{aligned}\Delta zim_t = \beta_{0i} &+ \sum_{t=1}^{k-1} \beta_{1i}\Delta zim_{t-i} + \sum_{t=1}^{k-1} \beta_{2i}\Delta sa_{t-i} + \sum_{t=1}^{k-1} \beta_{3i}\Delta exch_{t-i} + \sum_{t=1}^{k-1} \beta_{4i}\Delta fuel_{t-i} \\ &+ \sum_{t=1}^{k-1} \beta_{5i}\Delta vmi_{t-i} + \sum_{t=1}^{k-1} \beta_{6i}\Delta worldgr_{t-i} \\ &+ \beta_7(zim - \emptyset_1 sa - \emptyset_2 exch - \emptyset_3 fuel)_{t-1} + \beta_{8i}D_t + \mu_t \qquad (3)\end{aligned}$$

in which case all the variables are in logs and $\Delta\Delta$ is the first difference operator. $zim, sa, exch zim, sa, exch$, $fuel fuel$, $vmi vmi$ and $worldgr worldgr$ stand for Zimbabwe's CPI, South African CPI, South African Rand/US Dollar exchange rate, domestic petroleum prices, volume of manufacturing index and World Bank grain prices, respectively. $D_t D_t$ is a vector of dummies to account for outliers on specific dates and $\mu_t \mu_t$ is a white noise error term. A priori expectations of the signs of sa sa and $fuel fuel$ are positive. However, $exch exch$ is expected to have a negative sign.

The portion of the equation in parentheses is the error correction mechanism. $zim - \emptyset_1 sa - \emptyset_2 exch - \emptyset_3 fuel$ $zim - \emptyset_1 sa - \emptyset_2 exch - \emptyset_3 fuel$ is the error correction term and it is equal to zero when $zim zim$, $sa sa$, $exch$ $exch$ and $fuel fuel$ are in their equilibrium state. $\beta_0 \beta_0$ is the intercept while $\beta_1 \beta_1$, $\beta_2 \beta_2$, β_3, $\beta_4 \beta_4$, $\beta_5 \beta_5$ and $\beta_6 \beta_6$ are estimates of the short-term effects of movements to zim, $sa sa$, $exch$ $fuel$ $exch$ $fuel$, $vmi vmi$ and $worldgr worldgr$, respectively, on $zim_t zim_t$. $\beta_7 \beta_7$ estimates the speed of return to equilibrium after a deviation. A priori, the ECM predicts that -1 < $\beta_7 \beta_7$ < 0. The coefficients $\emptyset_1 \emptyset_1$, $\emptyset_2 \emptyset_2$ and $\emptyset_3 \emptyset_3$ estimate the long-run effects that a one-unit-increase in $sa sa$, $exch$ $exch$ and $fuel fuel$, respectively, has on $zim_t zim_t$. These long-term effects are to be distributed over future time periods according to the rate of error correction, $\beta_7 \beta_7$. The data sets for the variables considered were obtained from various periodic publications that include Zimbabwe Statistical Agency (Zimstat), Reserve Bank of Zimbabwe (RBZ), the South African Reserve Bank and the World Bank.

4. Empirical results

Stationarity tests were conducted to investigate the time series properties of the variables before carrying out cointegration tests. Unit root tests were carried out using the Augmented Dickey-Fuller (ADF) test and results are presented in Table 2.[6]

Table 2: Unit root tests: January 2010 – December 2015

Variable	Augmented Dickey-Fuller test (p values)							
	Intercept				Intercept and trend			
	Levels	No. of lags	1st difference	No. of lags	Levels	No. of lags	1st difference	No. of lags
Zimbabwe CPI (zim)	0.10	2	0.00	1	0.99	5	0.00	2
Zimbabwe food CPI (zimf)	0.26	4	0.01	1	0.87	3	0.00	2
Zimbabwe non-food tradables CPI (zimnft)	0.14	6	0.00	3	0.99	2	0.00	2
South Africa CPI (sa)	0.97	1	0.00	2	0.12	6	0.00	3
South Africa food CPI (saf)	0.99	5	0.00	4	0.19	3	0.00	4
South Africa non-food tradables CPI (sanft)	0.91	3	0.00	2	0.16	5	0.00	2
SA/US exchange rate (exch)	0.99	4	0.00	2	0.86	2	0.00	1
Domestic fuel price (fuel)	0.89	1	0.02	1	0.99	3	0.01	4
Volume of manufacturing index (vmi)	0.05	2	0.00	1	0.07	2	0.00	1
World Bank grain price (worldgr)	0.89	0	0.00	0	0.86	0	0.00	0

Note: Values reported are probabilities

As shown in Table 2, all the variables seem to have one unit root or are not stationary in levels.[7] Unit root tests were conducted for the same variables in first difference and all the variables were found to be stationary. The implication for these results is that all three models' variables are expected to be cointegrated given the relationship explained earlier. As a first step in testing for cointegration, four variable unrestricted vector autoregressive (VAR) models for Models 1, 2 and 3 were estimated. VAR models' lag lengths were determined using the results of the lag length criteria.

Tests for cointegration were conducted using the Johansen cointegration test (Johansen, 1988). The Johansen cointegration trace eigenvalue test results suggested one co-integrating vector for each of the three models, as reported in Table 3.

Table 3: Cointegration analysis

Model 1 (overall CPI)				
		Rank test		
	Null hypothesis	r = 0	r ≤ 1	r ≤ 2
	Eigenvalues	0.39	0.22	0.09
	Trace statistic	61.16	25.12	7.22
	0.05 critical value	47.86	29.80	15.49
	Probability value	0.00	0.16	0.55
Standardized eigenvector α_i				
	zim	sa	exch	fuel
	1.00	-0.36	0.41	-0.21
	Standard errors	0.17	0.21	0.11
	t-value	-2.12	1.95	-1.91
Standardized adjustment coefficient α_i				
	-0.03	0.02	0.08	-0.09
Standard errors	0.01	0.01	0.04	0.02
t-value	-3.65	1.90	2.00	-4.50

Note: Model 1 VAR lag length is one and cointegration tests performed using lag length of zero. Sample: 2010M01:2015M12.

Model 2 (food CPI)				
		Rank test		
	Null hypothesis	r = 0	r ≤ 1	r ≤ 2
	Eigenvalues	0.45	0.24	0.08
	Trace statistic	67.16	25.29	5.80
	0.05 critical value	47.86	29.80	15.49
	Probability value	0.00	0.15	0.72
Standardized eigenvector α_i				
	zimf	saf	exch	fuel
	1.00	-0.13	0.37	-0.44
	Standard errors	-0.07	-0.16	-0.15
	t-value	1.86	-2.31	2.93
Standardized adjustment coefficient α_i				
	-0.04	-0.02	0.11	-0.13
Standard errors	-0.01	-0.01	-0.06	-0.03
t-value	4.00	2.18	-1.83	4.33

Note: Model 2 VAR lag length is two and cointegration tests performed using lag length of one. Sample: 2010M01:2015M12.

	Model 3 (non-food tradables CPI)			
		Rank test		
	Null hypothesis	r = 0	r ≤ 1	r ≤ 2
	Eigenvalues	0.44	0.34	0.15
	Trace statistic	83.71	26.59	11.97
	0.05 critical value	47.86	29.80	15.49
	Probability value	0.00	0.12	0.62
Standardized eigenvector α_i				
	zimnft	sanft	exch	fuel
	1.00	-0.38	0.16	-0.22
	Standard errors	-0.12	-0.05	-0.04
	t-value	3.17	-3.20	5.50
Standardized adjustment coefficient α_i				
	-0.11	0.06	0.38	-0.41
Standard errors	-0.03	-0.03	-0.18	-0.08
t-value	3.67	-1.86	-2.11	5.13

Note: Model 3 VAR lag length is two and cointegration tests performed using lag length of one. Sample: 2010M01:2015M12.

The standardized eigenvectors, β_i, and adjustment coefficients, $\alpha_i\alpha_i$, for the three models are also reported in Table 3. As can be seen from the results in Table 3, the null hypothesis of no cointegrating vector is rejected for all three models, at a one-per-cent level of significance. The trace test indicates one cointegrating vector for all three models, at a five-per-cent level of significance. The estimated cointegrating vectors for Model 1, 2 and 3 are shown in Table 4.

Table 4: Standardized cointegrating vectors

Explanatory variable	Cointegrating vectors
Model 1: EC-overall CPI	[zim - 0.36sa + 0.41exch - 0.21fuel]
Model 2: EC-food CPI	[zimf - 0.13saf + 0.37exch - 0.44fuel]
Model 3: EC-non-food tradables CPI	[zimnft - 0.38sanft + 0.16exch - 0.22fuel]

The coefficients of the three models' cointegrating vectors have the anticipated signs. For Model 1, the estimate of the long-run coefficient for $sasa$, at 0.36, shows that during the period of study, a 1.0% increase in South Africa's overall CPI entails that Zimbabwe's overall price level will increase by 0.36% (see Table 4). Similarly, in the long run, a 1.0% increase in domestic fuel prices is associated with a 0.21% increase in Zimbabwe's overall price level, while a 1.0% depreciation of the South African Rand against the US Dollar is associated with a 0.41% decrease in Zimbabwe's price level in the long run. On the other hand, a 1.0% increase in South Africa's food CPI entails a 0.13% increase in Zimbabwe's food price level, while a 1.0% increase in domestic fuel prices is associated with a 0.44% increase in Zimbabwe's food price level. Conversely, a 1.0% depreciation of the South African Rand against the US Dollar is associated with a 0.37% decrease in Zimbabwe's food price level in the long run. These results are more or less replicated in Model 3.

Tests for weak exogeneity were conducted for the three models and the results are shown in Table 5.

Table 5: Test results for weak exogeneity

Model 1: Overall CPI				
	zim	sa	exch	fuel
p-value	0.05	0.99	0.14	0.12
Model 2: Food CPI				
	zimf	saf	exch	fuel
p-value	0.00	0.97	0.16	0.65
Model 3: Non-food tradables CPI				
	zimnft	sanft	exch	fuel
p-value	0.00	0.85	0.10	0.78

Note: A significant [p-value] denotes rejection of weak exogeneity. (See Doornik and Hendry, 1992.)

The variables $sasa$, $safsaf$, $sanft\ sanft$, $exchexch$ and $fuelfuel$ were found to be individually weakly exogenous at a 10% significance level, while zim, zim, $zimf$ $zimf$ and $zimnft\ zimnft$ are not. The implication of these results is that, in each case, there is no contemporaneous feedback relations from zim,zim, $zimfzimf$ and $zimnft\ zimnft$ to the respective explanatory variables in each cointegrating equation. As such, the study applied a single ECM for each of the three models. The single ECM specifications for the three models are discussed below.

Single ECMs for Zimbabwe's CPI

We discuss the general to specific modelling technique and estimation results for the three single ECMs specified for the three dependent variables: overall CPI, food CPI and non-food tradables CPI. We also conduct model diagnostic tests in order to analyze the properties of the three model specifications.

General to specific modelling

The error correction models for overall, food and non-food tradables' CPIs for Zimbabwe were developed from general models, which were sequentially reduced to empirically constant parsimonious models following an approach similar to Hendry's (1995: 365) general-to-specific modelling strategy. The three general models were estimated with five lags of each variable in first differences and the respective error correction terms (see Appendix 2). The transformation of each model was conducted by removing the longest lag of each variable with low t t-values and then checking the soundness of the simplification using FF-tests and the Schwarz criterion. As reported in Appendix 3, the FF statistics for all model pairs show that none of the reduction steps is significant while the Schwarz criteria becomes increasingly negative throughout the steps. In addition, when moving from the general to the parsimonious models, the standard errors (not reported) progressively decline. Three parsimonious single ECMs were estimated for Zimbabwe's overall, food and non-food tradables' CPIs. The results are shown in Table 6.

Table 6: Single ECMs for Zimbabwe's CPI components (January 2010 – December 2015)

Model 1: Overall CPI (zim)			Model 2: Food CPI (zimf)			Model 3: Non-food tradables CPI (zimnft)		
Variable	Coefficient	t-Stat	Variable	Coefficient	t-Stat	Variable	Coefficient	t-Stat
C	0.07	4.65	C	0.17	7.22	C	0.18	5.52
ec_1_{t-1}	-0.03	-4.60	ec_2_{t-1}	-0.06	-7.21	ec_3_{t-1}	-0.08	-5.51
Δvmi_{t-2}	-0.01	-3.08	$\Delta zimf_{t-1}$	0.17	1.91	$\Delta sanft_{t-2}$	0.19	2.75
$\Delta fuel_{t-3}$	0.07	2.00	$\Delta fuel_{t-1}$	-0.10	-2.79	Δvmi_{t-2}	-0.01	-3.95
Δzim_{t-4}	-0.11	-1.68	$\Delta exch_{t-2}$	0.05	2.59	$\Delta sanft_{t-3}$	-0.13	-2.02
$\Delta fuel_{t-4}$	-0.06	-1.86	$\Delta worldgr_{t-2}$	0.03	2.65	$\Delta fuel_{t-3}$	0.05	2.28
D2011M12	-0.03	-8.26	Δvmi_{t-3}	-0.01	-2.14	$\Delta fuel_{t-4}$	-0.04	-1.82
D2012M01	0.03	8.87	$\Delta fuel_{t-4}$	-0.08	-2.24	Δvmi_{t-4}	0.02	4.66
			$\Delta zimf_{t-5}$	-0.29	-3.89	$\Delta zimnf_{t-5}$	-0.28	-3.22
			D2010M12	-0.02	-5.16	Δvmi_{t-5}	0.02	4.65
			D2013M02	0.02	5.25	D2011M07	0.01	4.65
						D2013M02	0.01	3.78
Model 1: Overall CPI			Model 2: Food CPI			Model 3: Non-food tradables CPI		
R^2	0.78		R^2	0.70		R^2	0.72	
Adjusted R^2	0.75		Adjusted R^2	0.64		Adjusted R^2	0.66	
F statistic	29.2		F statistic	12.74		F statistic	12.73	
Prob (F stat.)	0.00		Prob (F stat.)	0.00		Prob (F stat.)	0.00	

The inclusion of dummy variables in all three models was motivated by the observation that in each case, after estimating the respective general models and residuals plotted, there were particularly large outliers on specific dates and the residuals were not normally distributed. In order to improve distribution of the residuals to near normal, dummy variables were included to effectively remove those observations. Dummy variables were used just like any other explanatory variable in the regression models. The interpretation of each estimated coefficient on the dummy variable was taken to closely match the residual that the dummied observation would have taken if the dummy variable had not been included (Brooks, 2014).

Model 1: Overall CPI

The general to specific modelling process yielded a parsimonious single ECM (Model 1), with Zimbabwe's overall CPI as the dependent variable. The error correction term for Model 1 was included as one of the independent variables. As shown in Table 6, changes to world grain prices, the South African overall CPI and the South African Rand/US Dollar exchange rate do not have short-run influences on the current overall price level in Zimbabwe. However, Zimbabwe's overall CPI, domestic fuel prices and domestic volume of manufacturing index, at various lags, were found to be significant determinants of the current price level in Zimbabwe in the short run. Among the included explanatory variables, none was found to affect domestic inflation contemporaneously. The coefficients of the second lag of the volume of manufacturing index are negative and statistically significant, consistent with the hypothesis that manufacturing production affects supply of non-food products. The fourth lag of domestic fuel prices, though significant, carries a wrong sign. While movements to the exchange rate and the South African overall CPI do not appear to influence the level of domestic CPI in the short run, their effects are rather transmitted through the error correction mechanism.

The estimate for the error correction coefficient is -0.03. The coefficient is statistically significant, implying that South African overall CPI, the South African Rand/US Dollar exchange rate and domestic fuel prices are long-run determinants of domestic inflation. The error correction coefficient measures the speed of return to equilibrium after a deviation from the equipoise state. This indicates a relatively low rate of adjustment in that about 3 per cent of the disequilibrium is corrected every month for equilibrium to be restored. The goodness of fit of the specification, R^2R^2 , was found to be 0.78, indicating that about 78 per cent of variations in Zimbabwe's CPI was being explained by the explanatory variables included in Model 1. The overall regression for Model 1 is significant at a one-per-cent level, as explained by the FF statistic and its corresponding probability.

Model 2: Food CPI

A second single ECM (Model 2) was estimated, with Zimbabwe's food CPI as the dependent variable while the South African food CPI, the South African Rand/US Dollar exchange rate, domestic fuel prices, domestic volume of manufacturing index and World Bank grain prices were included as independent variables. Model 2 error correction term was also included. The model estimation results in Table 6 show that the short-run variations in Zimbabwe's food price level are explained by domestic food and fuel prices, the exchange rate, the domestic level of economic activity, as measured by the volume of manufacturing index as well as World Bank grain prices, while South African food prices do not. The first and fourth lags of domestic fuel prices have a negative influence on the country's short-run price level. The exchange rate and international grain prices have positive effects on domestic inflation, taking effect with a two-month lag. The coefficient on the third lag of the volume of manufacturing index, though significant, carries a wrong sign.

Model 2 estimate for the error correction coefficient is -0.06, indicating that about 6 per cent of the adjustment is corrected every month for equilibrium to be restored. The goodness of fit of the specification was found to be 70 per cent. The overall regression for Model 2 is significant at a one-per-cent level, as explained by the FF statistic.

Model 3: Non-food tradables CPI

A third single ECM (Model 3) was estimated, with Zimbabwe's non-food tradables' CPI as the dependent variable. The independent variables included the South African non-food tradables' CPI, the South African Rand/US Dollar exchange rate, the volume of manufacturing index, domestic fuel prices, as well as the respective error correction term. The model estimation results in Table 5 show that all included explanatory variables at varying lags, except the exchange rate, were found to be significant determinants of the current price level in Zimbabwe in the short run. The adjustment to disequilibria is faster, at 8 per cent per month, compared to those for Model 1 and 2. The estimated reduced model explains about 72 per cent of the variations in the country's non-food tradables inflation. The overall regression for Model 3 is significant at a one-per-cent level.

Model diagnostic tests

In order to analyze the properties of the three parsimonious models, various tests were performed, including tests for serial autocorrelation (AR), autoregressive heteroskedasticity (ARCH), heteroskedasticity, regression functional form (RESET) and non-normal errors (normality test). As reported in Appendix 4, the diagnostics tests results for all three models suggest that they are generally specified as they indicate that the residuals are serially uncorrelated, homoscedastic and the parameters appear to be stable. In summary, it can be argued that Model 1, Model 2 and Model 3's residuals seem to behave well.

5. Conclusion

The study applies general to specific single error correction modelling techniques to investigate the determinants of Zimbabwe's overall, food and non-food tradables price level post the adoption of dollarization using monthly data from January 2010 to December 2015. The paper focuses on external factors (the South African rand/ US Dollar exchange rate, South African CPI, world grain prices, international crude oil prices, proxied by domestic fuel prices). Also included is the domestic level of economic activity, proxied by the volume of manufacturing index.

In the short run, changes to the overall domestic CPI are influenced by movements to the domestic overall CPI and fuel. The short-run variations in Zimbabwe's food price level are explained by lagged domestic food prices and world grain prices. In the short run, non-food tradables prices are determined by past domestic and South African non-food tradables prices and the level of domestic economic activity.

The main determinants of the country's overall, food and non-food tradables prices in the long run are the South African Rand/US Dollar exchange rate, South African overall CPI and domestic fuel prices. Depreciation of the South African Rand against the US Dollar, holding the South African CPI and domestic fuel prices constant, was found to result in the easing of prices in Zimbabwe. On the other hand, a rise in South African CPI, holding the Rand/US Dollar exchange rate and domestic fuel prices constant, was found to be associated with a rise in Zimbabwe's CPI. In addition, empirical results show that an increase in domestic fuel prices potentially exerts upward pressure on the country's price level. Nonetheless, exchange rate developments, international crude oil prices and CPI dynamics in South Africa remain beyond the country's control.

The medium to long-term drivers of inflation in Zimbabwe point to the sustained appreciation of the US Dollar against the South African Rand, a decline in international oil prices and subdued domestic economic activity. The country is experiencing low aggregate demand given the increasingly difficult macroeconomic environment characterized by liquidity and structural constraints, which have resulted in company closures and retrenchments, thereby negatively affecting consumers' purchasing power. The model estimated in this paper cannot explain the deflation but weak aggregate demand might be one explanation, although that it is not captured by the analysis.

If the current deflationary pressures are to worsen, this can lead to a deflationary spiral whereby prices continue to fall. This would ultimately lead to a further lowering of production levels which, in turn, is reflected in lower wages and lower aggregate demand by businesses and consumers, which then lead to further decreases in prices and further exposure to the dangers of deflation.

Suffice it to say, the ability of the country's fiscal and monetary authorities to cushion the country from the vulnerabilities of attributed external factors remain a challenge on the back of limited fiscal space and the dollarized regime. The country's central bank has virtually no control over monetary and exchange rate developments under a dollarized regime and, hence, cannot intervene to manage monetary and/or exchange rate disequilibria. There is, therefore, a need for Government to come up with measures that address both supply and demand-side challenges in order to boost economic activity, as a way of managing the potential negative consequences of deflation. On the supply side, authorities need to mobilize significant domestic public, private-sector and international funding in order to increase the capital stock, refurbish the existing infrastructure and invest in new infrastructure projects in order to increase the country's potential output. These measures will shore up both economic growth and employment and, ultimately, the price level.

Notes

1. Disinflation refers to a sustained decline in the rate of inflation, with its absolute value still above zero. Deflation, on the other hand, refers to a phenomenon where the rate of inflation becomes negative.

2. The index is a Laspeyres type with December 2012 as the base year. The new classification has 83 classes, 41 groups and 12 divisions, while the old classification had 12 major groups and 68 sub-groups. The number of items in the CPI basket was increased from 428 to 495. All CPI figures include vaslue added tax and excise duty.

3. The author derived non-food tradables CPI from the officially published overall and food CPIs.

4. Volume of manufacturing index is used to measure changes in the volume of production on a monthly basis. The indicators that are used for measuring the changes are: physical quantities produced, quantity of materials used, value of output produced and/or sales deflated to real values using the consumer price index (CPI) and number of man hours worked, together with the weights for the eleven subsectors to derive the indices.

5. See Mwase (2006), Nkunde (2006), Ocran (2007) and Aron et al. (2014).

6. ADF is called "unit root test"; the null hypothesis is that $y_t y_t$ has a unit root; is integrated of order one, $I(1)I(1)$ or higher.

7. While the CPI inflation rate in South Africa would be expected to be $I(0)I(0)$ given that the South African Reserve Bank (SARB) is in an inflation-targeting regime, the variable was found to be $I(1)I(1)$ during the period of study. This could be a result of the relatively short period being considered here.

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Appendix 1: Definition of variables and sources

Variable	Definition	Source
Zimbabwe CPI (zim)	Logarithm of Zimbabwe's overall consumer price index	ZIMSTAT
Zimbabwe food CPI (zimf)	Logarithm of Zimbabwe's food consumer price index	ZIMSTAT
Zimbabwe non-food tradables CPI (zimnft)	Logarithm of Zimbabwe's non-food tradables consumer price index	ZIMSTAT
South Africa CPI (sa)	Logarithm of South Africa's overall consumer price index	STATSSA
South Africa food CPI (saf)	Logarithm of Zimbabwe's overall consumer price index	STATSSA
South Africa non-food tradables CPI (sanft)	Logarithm of South Africa's non-food tradables consumer price index	STATSSA
SA/US exchange rate (exch)	Nominal South African Rand/US Dollar exchange rate	South African Reserve Bank
Domestic fuel price (fuel)	Domestic fuel price	ZIMSTAT
Volume of manufacturing index (vmi)	Volume of domestic manufacturing index	ZIMSTAT
World Bank grain price (worldgr)	World Bank grain price	World Bank

Appendix 2: General error correction models for overall and food CPIs

Model 1: Overall CPI	Number of variable lags				
Variable	1	2	3	4	5
ec_1_{t-i}	-0.03 (-1.91)				
Δzim_{t-i}	0.05 (0.37)	0.19 (1.71)	-0.04 (-0.41)	-0.20 (-1.79)	0.01 (0.10)
Δsa_{t-i}	0.00 (0.02)	0.19 (1.09)	-0.12 (-0.69)	0.40 (2.50)	-0.18 (-1.11)
$\Delta exch_{t-i}$	0.01 (0.54)	0.01 (0.45)	0.03 (1.56)	0.02 (0.86)	-0.01 (-0.45)
$\Delta fuel_{t-i}$	-0.03 (-0.69)	-0.01 (-0.20)	0.06 (1.19)	-0.10 (-2.09)	0.02 (0.60)
Δvmi_{t-i}	-0.01 (-1.01)	-0.02 (-2.53)	0.00 (0.03)	0.01 (0.53)	0.01 (0.75)
$\Delta worldgr_{t-i}$	-0.01 (-0.38)	0.03 (1.75)	0.02 (1.19)	-0.01 (-0.31)	0.00 (-0.10)
D2011M12	-0.03 (0.00)				
D2012M01	0.03 (0.00)				

Note: tt values are in parentheses. The error correction term for Model 1 is defined as ec_1 = [zim - 0.36sa + 0.41$exch$ - 0.21$fuel$], T = 66 [2010M01 2015M12] R-Squared = 0.86, Standard Error = 0.00, AR: F(2,30) 0.45 [0.64], ARCH: F(1,63) 0.70 [0.40], Normality: 8.88 [0.01], RESET: F(1,31) 2.22 [0.15].

Model 2: Food CPI	Number of variable lags				
Variable	1	2	3	4	5
ec_2_{t-i}	-0.07 (-3.10)				
$\Delta zimf_{t-i}$	0.26 1.75	-0.04 (-0.28)	0.00 (-0.02)	-0.03 (-0.23)	-0.20 (-1.85)
Δsaf_{t-i}	0.01 (0.12)	0.09 (0.84)	-0.10 (-0.99)	0.04 (0.37)	0.06 (0.52)
$\Delta exch_{t-i}$	-0.01 -0.24	0.05 (2.04)	0.03 (0.96)	0.01 (0.33)	0.01 (0.48)
$\Delta fuel_{t-i}$	-0.13 (-2.05)	-0.01 (-0.18)	-0.01 (-0.16)	-0.10 (-1.61)	0.02 (0.26)
$\Delta worldgr_{t-i}$	-0.01 (-0.75)	0.03 (2.16)	0.01 (0.34)	0.01 (0.59)	-0.01 (-0.86)
Δvmi_{t-i}	-0.01 (-0.61)	0.01 (0.95)	0.00 (0.34)	0.02 (1.68)	0.01 (1.07)
D2010M12	-0.02 (-2.97)				
D2013M02	0.02 (3.26)				

Note: t values are in parentheses. The error correction term for Model 2 is defined as $ec\_2 = [zimf - 0.13 saf + 0.37 exch - 0.44 fuel]$, T = 66 [2010M07 2015M12] R-Squared = 0.78, Standard Error = 0.00, AR 1 - 5: F(2,30) 1.05 [0.36], ARCH F(1,63) 0.00 [0.98], Normality 0.78 [0.68], RESET F(2,30) 1.75 [0.19].

Model 3: Non-food	Number of variable lags				
Variable	1	2	3	4	5
ec_3_{t-i}	-0.09 (-3.04)				
$\Delta zimnft_{t-i}$	0.17 (1.59)	0.13 (1.25)	0.06 (0.64)	-0.11 (-0.92)	-0.27 (-2.45)
$\Delta sanft_{t-i}$	0.03 (0.38)	0.17 (1.98)	-0.22 (-2.60)	0.05 (0.56)	-0.11 (-1.51)
$\Delta exch_{t-i}$	0.02 (1.22)	0.00 (0.08)	-0.01 (-0.73)	0.03 (1.77)	0.01 (0.69)
$\Delta fuel_{t-i}$	-0.03 (-0.79)	0.04 (1.22)	0.04 (1.15)	-0.09 (-2.75)	-0.03 (-1.04)
Δvmi_{t-i}	-0.01 (-1.39)	-0.01 -(2.43)	0.00 (0.07)	0.02 (3.01)	0.01 (2.76)
D2011M07	0.02 (5.14)				
D2013M02	0.01 (3.11)				

Note: t values are in parentheses. The error correction term for Model 3 is defined as $ec\_3ec\_3 = [zimf - 0.38 saf + 0.16 exch - 0.22 fuel]$, T = 66 [2010M07 2015M12] R-Squared = 0.81, Standard Error = 0.00, AR 1 - 2: F(2,35) 0.51 [0.61], ARCH F(2,61) 1.29 [0.28], Normality 0.46 [0.79], RESET F(2, 35) 3.99 [0.03].

Appendix 3: F-statistics and Schwartz criteria for sequential reduction of general ECM to Parsimonious models

Model 1: Overall CPI	Models					
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
F Statistic	-	0.35 [0.91] (6, 32)	0.60 [0.62] (3, 39)	1.43 [0.23] (5, 42)	1.41 [0.23] (4, 47)	0.43 [0.86] (6, 51)
Schwarz criteria, SC	-7.42	-7.77	-7.92	-8.05	-8.21	-8.50
K (no. of unrestricted parameters)	34	28	25	21	17	11

Note: The three entries on the F statistic row are approximate FF statistic for testing the null hypothesis, the tail probabilities (in square brackets) and the degrees of freedom for the F statistic (in parentheses).

Model 1 is the general model containing five lags of each variable in first differences and the error correction term. Model 2 is Model 1 excluding the fifth lags of $\boldsymbol{zim}$, $\boldsymbol{sa}$, $\boldsymbol{exch}$, $\boldsymbol{fuel}$, $\boldsymbol{vmi}$ and $\boldsymbol{worldgr}$. Model 3 is Model 2 excluding the fourth lags of $\boldsymbol{exch}$, $\boldsymbol{vmi}$ and $\boldsymbol{worldgr}$. Model 4 is Model 3 excluding the third lags of $\boldsymbol{zim}$, $\boldsymbol{sasa}$, $\boldsymbol{exch}$, $\boldsymbol{vmi}$ and $\boldsymbol{worldgr}$. Model 5 is Model 4 excluding the second lags of $\boldsymbol{zim}$, $\boldsymbol{sa}$, $\boldsymbol{exch}$, and $\boldsymbol{fuel}$ and Model 6 is Model 5 excluding the first lags of $\boldsymbol{zim}$, $\boldsymbol{sasa}$, $\boldsymbol{exch}$, $\boldsymbol{fuel}$, $\boldsymbol{vmi}$ and $\boldsymbol{worldgr}$.

Model 2: Food CPI	Models					
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
F Statistic		0.67 [0.65] (5, 32)	0.70 [0.63] (5, 39)	0.87 [0.51] (5, 42)	0.92 [0.46] (4, 48)	0.72 [0.58] (4, 52)
Schwarz criteria, SC	-6.83	-7.04	-7.31	-7.55	-7.77	-7.98
K (no. of unrestricted parameters)	34	29	24	19	15	11

Note: The three entries on the F statistic row are approximate F statistic for testing the null hypothesis, the tail probabilities (in square brackets) and the degrees of freedom for the F statistic (in parentheses).

Model 1 is the general model containing five lags of each variable in first differences and the error correction term. Model 2 is Model 1 excluding the fifth lags of $\boldsymbol{saf}$, $\boldsymbol{exch}$, $\boldsymbol{fuel}$, $\boldsymbol{worldgr}$ and $\boldsymbol{vmi}$. Model 3 is Model 2 excluding the fourth lags of $\boldsymbol{zimf}$, $\boldsymbol{saf}$, $\boldsymbol{exch}$, $\boldsymbol{worldgr}$ and $\boldsymbol{vmi}$. Model 4 is Model 3 excluding the third lags of $\boldsymbol{zimf}$, $\boldsymbol{saf}$, $\boldsymbol{exch}$, $\boldsymbol{fuel}$ and $\boldsymbol{worldgr}$. Model 5 is Model 4 excluding the second lags of $\boldsymbol{zimf}$, $\boldsymbol{saf}$, $\boldsymbol{fuel}$ and $\boldsymbol{vmi}$ $\boldsymbol{vmi}$ and Model 6 is Model 5 excluding the first lags of $\boldsymbol{saf}$, $\boldsymbol{exch}$, $\boldsymbol{worldgr}$ and $\boldsymbol{vmi}$.

Model 3: Non-food Tradables CPI	Models					
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
F Statistic		1.42 [0.25] (3, 37)	1.01 [0.40] (3, 40)	0.61 [0.61] (3, 43)	0.75 [0.53] (3, 46)	1.43 [0.23] (5, 49)
Schwarz criteria, SC	-8.16	-8.25	-8.36	-8.51	-8.65	-8.84
K (no. of unrestricted parameters)	29	26	23	20	17	12

Note: The three entries on the FF statistic row are approximate F statistic for testing the null hypothesis, the tail probabilities (in square brackets) and the degrees of freedom for the F statistic (in parentheses).

Model 1 is the general model containing five lags of each variable in first differences and the error correction term. Model 2 is Model 1 excluding the fifth lags of $\boldsymbol{sanft}$, $\boldsymbol{exch}$ and $\boldsymbol{fuel}$. Model 3 is Model 2 excluding the fourth lags of $\boldsymbol{zimnft}$, $\boldsymbol{sanft}$ and $\boldsymbol{exch}$. Model 4 is Model 3 excluding the third lags of $\boldsymbol{zimnft}$, $\boldsymbol{exch}$ and $\boldsymbol{vmi}$. Model 5 is Model 4 excluding the second lags of $\boldsymbol{zimnft}$, $\boldsymbol{exch}$ and $\boldsymbol{fuel}$ and Model 6 is Model 5 excluding the first lags of $\boldsymbol{zimnft}$, $\boldsymbol{sanft}$, $\boldsymbol{exch}$, $\boldsymbol{fuel}$ and $\boldsymbol{vmi}$.

Appendix 4: Diagnostic tests for the Parsimonious models

Dependent variable	AR	ARCH	Breusch-Pagan/ Cook-Weisberg heteroskedasticity	Normality	RESET
Model 1: Overall CPI	F(2,54) 2.05 [0.14]	F(1,64) 1.37 [0.25]	F(10,56) 0.24 [0.99]	11.30 [0.00]	F(1,55) 0.77 [0.38]
Model 2: Food CPI	F(2,53) 0.51 [0.60]	F(1,63) 2.09 [0.15]	F(10,55) 0.80 [0.62]	0.25 [0.88]	F(1, 51) 1.85 [0.13]
Model 3: Non-food tradables CPI	F(2,52) 0.53 [0.59]	F(1,63) 0.51 [0.48]	F(11, 54) 2.57 [0.01]	0.88 [0.64]	F(1, 53) 5.13 [0.03]

Note: p-values in parentheses

H_0 for autoregressive conditional heteroskedasticity (ARCH) tests is the absence of autocorrelation. H_0 for the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity is constant variance. H_0 for Normality corresponding to those of a normal distribution. H_0 for the Ramsey RESET test is for functional form or model mis-specification.

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Contact Us
African Economic Research Consortium
Consortium pour la Recherche Economique en Afrique
Middle East Bank Towers,
3rd Floor, Jakaya Kikwete Road
Nairobi 00200, Kenya
Tel: +254 (0) 20 273 4150
communications@aercafrica.org