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Analysis of Factors Affecting Food Price Fluctuations in Rwanda

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Abstract: ***Commodity food prices have soared upwards dramatically in recent years. Unceasing upsurge in food prices is a big challenge for policy makers at global level and the instability of commodity prices is a major concern for most developing countries. Rwanda has not been out of danger from the negative consequences. This study aims at analyzing the factors causing the food prices to fluctuate in Rwanda. Using secondary data obtained from National Institute of Statistics of Rwanda (NISR) and International Monetary Fund (IMF) for period from 2009 to 2018; both univariate and multivariate analyses were conducted. Research findings revealed that price series of food, energy, education, health, transport, communication, exchange rate and GDP, all present a unit root meaning that they are not stationary at level and they have become stationary after first difference. Research also revealed that prices of food, energy, education, health, transport, communication, exchange rate and GDP are cointegrated and Johansen Cointegration Test confirmed that there is a stable and long run equilibrium relationship between food price and prices of energy, education, health, transport, communication, exchange rate and GDP. Research results shown that the coefficients R squared (R^2) and adjusted R squared (R^2) point out that about 92% of the variation of food's prices in Rwanda is explained by changes in prices of energy, education, health, transport, communication, exchange rate and GDP. Researcher recommends that government should put strong control on monetary policies, foreign exchange market and also particularly on prices of various indispensable products such as fuel, water, electricity, transport, communication, transport, education and health to ensure prices remain in band whereby encouraging sellers and buyers in equilibrium for better welfare of all. Also government should increase resilience of producers and consumers to deal with price changes by supporting contract farming and price insurance mechanisms on the production side and by improving access to financial services on the consumer side.***

Keywords: Food Price, Food Price Fluctuations, Time Series, Stationarity, Cointegration, Error Correction Model

1. Introduction

Today, the world is experiencing a dreadful food price fluctuations. Globally, commodity food prices have soared in dramatic fashion in recent years after several decades of relative stability and low levels. Specifically, commodity food prices increased dramatically between late 2006 and mid-2008. In 2008, food prices globally rose to unprecedented levels (FAO, 2011).

According to Commodity Research Bureau (2009), the global inflation and food inflation rates at global level stand at 16.5 and 30.2 percent respectively by November 06, 2007. This high food inflation perseveres in most of the countries in the world. During the first three months of 2008, international nominal prices of all major food commodities touched their highest levels in nearly 50 years although prices in real terms were the uppermost in nearly 30 years and by reaching high levels later on. Despite the fact that there was a marked drop in the next year, prices spiked yet again in mid-2011, over and above 2008 levels and remaining relatively high through the rest of year and all of 2012, they caused serious concerns about a repeat of the 2006–2008 food crisis. Basically, following declines in global food prices in 2009, even higher and more volatile prices have returned, with high food inflation in some countries like China that did not happen in 2007-2008 and a low food inflation in other countries like Rwanda (FAO, 2018).

The price upsurges reverse a previous trend when real prices of food commodities declined at an average annual rate of 0.6 percent from 1960 to 1999, approaching remarkable lows. The persistent price decline can be attributed to farmers' success in keeping crop yields ahead of intensifying worldwide food demand. Even though the global population grew by 3.8 billion or 122.9 percent between 1961 and 2010, net per capita food production improved by 49 percent over this period (FAO, 2011). Advances in crop breeding and an extension of agricultural land drove this rise in production, as farmers cultivated an additional 434 million hectares between 1961 and 2010. Food price instability has increased dramatically since 2006. According to the United Nations Food and Agriculture Organization (FAO), the standard deviation; the measurement of deviation from the average for food prices between 1990 and 1999 was 7.7 index points, but it amplified to 22.4 index points in the 2000-2012 period (FAO, 2018).

Intensifying in food prices have become a matter of great public interest in recent years. While the Western world is relatively unaffected by price fluctuations as most people are not price sensitive to food products, people in poorer regions including Rwanda are less fortunate when prices rise. Small variations in food price in poorer regions can mean the difference between having enough food for the day and going hungry. The circumstance that food has become increasingly expensive is also reflected by the United Nations Food and Agricultural Organization (FAO) Food Price Index. In 2011, the index stood at its all-time high with food prices having doubled since 2004 (FAO, 2011). As before, the food and nutrition security impact of high prices falls disproportionately on those who can least afford it. Rising food costs, along with other shocks such as drought, floods and economic crises can have a major impact on food and nutrition security as these push the most vulnerable households further into poverty and weaken their ability to access adequate food.

These hardships can force poor families to sell off assets or forego other fundamentals that create a lifelong poverty trap that becomes ever harder to discharge. Predominantly for children, even short-term worsening of nutrition can lead to perpetual detrimental effects. Following decreases in global food prices in 2009, even higher and more unstable prices have returned, with high food inflation in India and China that did not happen in 2007-2008 (FAO, 2018). As before, the food and nutrition security impact of high prices falls disproportionately on those who can least manage to pay for it.

Intensifying food costs, along with other shocks such as drought, floods and economic crises can have a major effect on food and nutrition security as these push the most vulnerable households further into poverty and weaken their ability to access adequate food. These hardships can force poor families to sell off assets or forego other essentials that create a long lasting poverty trap that becomes ever harder to escape. Particularly for children, even short-term worsening of nutrition can lead to permanent detrimental effects. It is an axiom that food price fluctuations is common in this era of globalization and agricultural industrialization particularly with occurrence of jolts. Even though the food market situation differs from country to country and future evolution remains highly indeterminate. Not all countries or all poor households suffered equally at that time, of course, and a several countries, including Rwanda, were largely able to cushion domestic food prices from the dramatic soaring in global prices. The upsurge in food and energy prices has been propelling global inflation upwards in recent years.

In advanced economies, inflation doubled from about 2% several years ago to 4% in mid-2008, and in emerging economies it increased from about 4% to approximately 8%.

The relatively higher surge in emerging economy inflation is at least in part a concern of the larger weight of food in the consumption basket in countries with lower income per capita (IMF, 2018). Unceasing upsurge in food prices is a big challenge for policy makers at global level. The problem of the instability of commodity prices is a major concern for most developing countries. Rwanda has not been out of danger from the negative consequences. Being a developing country Rwanda is also facing challenges of food commodity price fluctuations.

It is evidently the bigger assignment to control the food item prices. Increase in food prices needs a great attention because it decreases the welfare of the poor households (World Bank, 2018).

Proliferations in agricultural commodity prices have been a significant factor driving up the cost of food and have led to a fuller awareness and a justifiably heightened concern about problems of food security and hunger, especially for developing countries including Rwanda. Consumer Price Index (CPI) in Rwanda, main gauge of inflation has increased 13.4 percent year-on-year in February of 2017, following 12 percent gain in the previous month. It was the highest inflation rate since March of 2009 as cost rose faster for food and non-alcoholic beverages (24.5 percent from 21.9 percent in January), namely for vegetables (+27.8 percent) and bread and cereals (+16.7 percent). Month-on-month, consumer prices went up 1.9 percent compared to 0.3 percent drop in the previous month. Inflation Rate in Rwanda averaged 6.19 percent from 1997 until 2017, reaching an all-time high of 28.10 percent in February of 1998 and a record low of -15.80 percent in February of 1999 (National Institute of Statistics of Rwanda, 2018). Tight market conditions for essential food commodities pose policy challenges. In order to take the right policy decisions, we need to understand what caused the current price spike, what the implications may be for prices and price volatility in the future. Since food price fluctuations hamper economic growth and they reduce the purchasing power of households. Therefore, this research aims to analyze factors causing food price fluctuate in Rwanda and hence improve this understanding and thereby contribute to sound policy formulation.

2. Research Methods and Procedures

This research has used a mixed methods. The research is quantitative in nature and used a non-experimental design including case study, hypotheses and longitudinal research designs to reach objectives of the whole undertaking. According to (Kothari, 2004) no single research design can solely be sufficient for a whole research process, hence the combination of many designs. In fact, some elements of case studies were involved in order to get reasonable findings. A case study is an in-depth study of a specific research problem rather than a sweeping statistical survey.

The case study research design is as well useful for testing whether a specific theory and model actually applies to phenomena in the real world. This study also conducted to test the hypotheses in order to enhance the understanding of the drivers of food prices. This research method is known as the hypothetico-deductive method and is characterized by the hypotheses, which are developed by logical reasoning and earlier empirical evidence and which are testable (Sekaran & Bougie, 2010). Quantitative research is appropriate for this study, as numerical data were collected to identify a relationship among variables under study.

Thus, the study followed a deductive research approach to confirm or disprove the logical assumption in the hypotheses and then the study is of a quantitative nature.

Researcher also used longitudinal design to enable to detect developments and changes in the characteristics of the target population at all levels.

Researcher appreciated the mixed approach because produces better results in terms of quality and scope. The mixed research designs approach is a way to come up with creative alternatives to traditional or more monolithic ways to conceive and implement adequate estimation. The research was conducted within the Republic of Rwanda and secondary data were retrieved from National Institute of

Statistics of Rwanda (NISR) and International Monetary Fund (IMF) to be used for the purpose of this research. Through documentary research, data for variable GDP were obtained by retrieving them from Rwanda GDP National accounts report, note that due to by the time of the research, data for GDP 2018 only three first quarters were published, the researcher estimated GDP for fourth quarter in order to arrive at estimate of GDP for the whole year of 2018. Also, through documentary research, data for variables; food price, energy, health, education, transport, communication were obtained by retrieving them from consumer price index and all data were for these variables were available for entire period under study. Regarding exchange rate variable, data were obtained from database of exchange rates published by IMF. To reach research objectives, dependent (response) variable that is food price and explanatory (stimulus) variables that are factors causing food prices to fluctuate (for purpose of this study we limited to prices of energy, health, education, transport, communication, GDP and exchange rate) were studied. As far as data processing is concerned, the researcher, having collected the reliable data, data processing and analysis were performed using econometrical software Eviews version 10.

Regarding to the nature of data, the analysis (both Univariate and multivariate) was afforded using statistical package software Eviews version 10 in order to generate models and coefficients. Univariate analysis was carried out to check whether individual variables are stationary or not.

Multivariate analysis was used to examine the relationship between food price and factors causing food prices to fluctuate. In the search for factors influencing the variability of food prices in Rwanda, the researcher, has adopted the following econometric model:

$Ft=\alpha+\beta1Nt+\beta2Et+\beta3Ht+\beta4Tt+\beta5Ct+\beta6Xt+\beta7Gt+\varepsilon t$, where F is food price, α is intercept, βi (where i range from 1 to 7) are regression coefficients, they are just parameters associated to the food prices and are to be estimated. N energy, H Health, E education, T transport, C Communication, X Exchange rate, G GPD, t is time and Ɛ is error term. The variables were transformed into logarithms to lead us to scale reducing and permit us to interpret the results in terms of elasticity. This leads us to write the equation in log-linear format for different variables and we obtain the following long-run equation of the variation of prices:

$$LogFt=\alpha+\beta1LogNt+\beta2LogEt+\beta3LogHt+\beta4LogTt+\beta5LogCt+\beta6LogXt+\beta7LogGt+\varepsilon t,$$

Also, cointegration analysis was conducted to establish longrun equilibrium relationship between variables. According to Gujarati,N.D. (2004), the regression of one time series variable on one or more time series variables every so often can give nonsensical or unauthentic results. This phenomenon is known as spurious regression. One way to safeguard against it is to authenticate if the time series are cointegrated. The cointegration analysis is indispensable in the field of analysis of the economic series where, the risk of estimating the regression of spurious relationships and interpreting the results in a flawed way is very high. In that case, such regressions give fortuitous results due to correlation between the series affected by a stochastic trend. Consequently, this regression is not real because it simply arises from a relationship between two trends. Since, cointegrating regression led to conclude a long run equilibrium relationship between variables; researcher proceeded to error correction modeling to examine the existence of equilibrium or disequilibrium between short run dynamics and long run equilibrium.

3. Empirical Results and Discussion

3.1 Analysis of the Stationarity for Dependent Variable

The lag selected for all the series of food prices in logarithm form by the criteria AIC (Akaike Info Criterion), SIC (Schwarz Info Criterion) and HQC (Hannan-Quinn Criterion) is equal to 12. The statistics calculated for these series are compared with the critical values under the null hypothesis of the existence of a unit root that means that if we fail to reject the null hypothesis, a series is non-stationary. To draw conclusion about stationarity of time series (food prices collected from February 2009 to December 2018), the researcher has also referred to the p-values assumed by the test at a significance level of 5%. The results of ADF test for food price series are presented in the table 1 below:

Table 1: Unit Root Test for Logarithm of Food Prices

Variable name	Model	Test statistic	P-Value
LogF	Model 1	1.262627	0.9470
	Model 2	-1.291324	0.6319
	Model 3	-2.133742	0.5214

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

The results shown in the table 1 above lead us to conclude that we fail to reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend. The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (0.9470, 0.6319 and 0.5214 respectively) are not less than 5%.

Therefore, the series of logarithm of food prices are not stationary at level since Augmented Dickey Fuller test revealed the existence of unit root. The existence of unit root in food prices gives us a signal that if we associate series of food price with another non-stationary time series will lead to nonsense or spurious regression.

Hence, it is essential to convert series into first difference in order to make it stationary. The transformation of food prices into 1stdifference resulted to stationary food price series and we are confident that association with another stabilized variable will give us long run relationship.

3.2 Analysis of the Stationarity for Independent Variables

Similarly to dependent variable, the lag selected for all the series of independent variables in logarithm form by the criteria AIC (Akaike Info Criterion), SIC (Schwarz Info Criterion) and HQC (Hannan-Quinn Criterion) is equal to 12. The statistics calculated for these series are compared with the critical values under the null hypothesis of the existence of a unit root that means that if we fail to reject the null hypothesis, a series is non-stationary. To draw conclusions about stationarity of time series of independent variables (data collected for events took place from February 2009 to December 2018), the researcher referred to the p-values assumed by the test at a significance level of 5%.

3.2.1 Unit root test for logarithm of energy prices

The prices of energy in logarithm are not generally stationary at level even though the results presented in the table 2 reveal that the series of the logarithm of the prices of energy presents neither an intercept nor a trend. A test statistic of 2.383689 with a p-value of 0.0187 for the model 1 (a model without constant) indicates that we should reject the null hypothesis in a favor of alternative hypothesis that series has no unit root. However, a test statistic of 0.538117 with a corresponding p-value of 0.9874 for the model 2 (a model with constant) and a test statistic of -1.802171 with a corresponding p-value of 0.6976 for the model 3 (a model with constant and trend) lead us to fail reject the null hypothesis of presence of unit root. Since all models do not yield same results better to proceed to 1stdifference to get a stationary series.

Table 2: Unit Root Test for Logarithm of Energy Prices

Variable name	Model	Test statistic	P-Value
LogN	Model 1	2.383689	0.0187
	Model 2	0.538117	0.9874
	Model 3	-1.802171	0.6976

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

3.2.2 Unit root test for logarithm of education prices

The prices of education in logarithm form are not stationary at level. The results shown in the table 3 below lead us to conclude that we fail to reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend. The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (0.9961, 0.8338 and 0.1100 respectively) are not less than 5%.

Table 3: Unit Root Test for Logarithm of Education Prices

Variable name	Model	Test statistic	P-Value
LogE	Model 1	2.402492	0.9961
	Model 2	-0.731216	0.8338
	Model 3	-3.104833	0.1100

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

3.2.3. Unit root test for logarithm of health prices

Expenses on health matters is also an element that causes food price to fluctuate over time. The results shown in the table 4 below lead us to conclude that we fail to reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend.

The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (0.9818, 0.8395 and 0.5309 respectively) are not less than 5%.

Table 4: Unit Root Test for Logarithm of Health Prices

Variable name	Model	Test statistic	P-Value
LogH	Model 1	1.782466	0.9818
	Model 2	-0.709117	0.8395
	Model 3	-2.116765	0.5309

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

3.2.4. Unit root test for logarithm of transport prices

Transport cost is also an element that disturbs food price and hence causes price fluctuations over time. The results shown in the table 5 below lead us to conclude that we fail to reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend.

The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (0.9989, 0.8406 and 0.6706 respectively) are not less than 5%.

Table 5: Unit Root Test for Logarithm of Transport Prices

Variable name	Model	Test statistic	P-Value
LogT	Model 1	2.834818	0.9989
	Model 2	-0.704865	0.8406
	Model 3	-1.856502	0.6706

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

3.2.5. Unit root test for logarithm of communication prices

Communication is becoming a giant driver in our daily operations and affects in one way to another our choices given scarce resources and immense wants and needs. The results shown in the table 6 below lead us to conclude that we fail to reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend. The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (0.2950, 0.3004 and 0.7445 respectively) are not less than 5%.

Table 6: Unit Root Test for Logarithm of Communication Prices

Variable name	Model	Test statistic	P-Value
LogC	Model 1	-0.970872	0.2950
	Model 2	-1.968493	0.3004
	Model 3	-1.701850	0.7445

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

3.2.6. Unit root test for logarithm of exchange rate

Movement of foreign exchange rate over time causes uncertainty on money market and eventually affect behavioural change of food price. The output presented in the table 7 below tells us that we cannot reject the null hypothesis (H0) of the presence of a unit root at of 5 % by considering various models where Model 1 is a model without constant or intercept, Model 2 is a model with constant or intercept and Model 3 is a model with constant and trend. The coefficients associated to model 1, model 2 and model 3 are not statistically significantly different from 0 at 5% as level of significance since their p-values (1.000, 0.9995 and 0.3932 respectively) are not less than 5%.

Table 7: Unit Root Test for Logarithm of Exchange Rate

Variable name	Model	Test statistic	P-Value
LogX	Model 1	5.507527	1.0000
	Model 2	1.634573	0.9995
	Model 3	-2.369904	0.3932

Source: Computed by the Researcher using eviews version 10.0 for data obtained from IMF exchange rate data

3.2.7. Unit root test for logarithm of GDP

Swings in GDP as one of macroeconomic variable affects inevitably other variables in the economy as well as prices including food prices. The outputs presented in the table 8 below reveal that the series of the logarithm of GDP presents a trend. Without a doubt, with, respectively, for both a test statistic of 4.286008 with a p-value of 1.0000 for the model 1 (a model without an intercept) and a test statistic of -0.381114 with a corresponding p-value of 0.9076 for the model 2 (a model with an intercept) the null hypothesis of presence of unit root is failed to be rejected even though it is rejected for the model 3 with constant and trend (Test statistic of -3.544488 and p-value of 0.0394).

Table 8: Unit Root Test for Logarithm of GDP

Variable name	Model	Test statistic	P-Value
LogG	Model 1	4.286008	1.0000
	Model 2	-0.381114	0.9076
	Model 3	-3.544488	0.0394

Source: Computed by the Researcher using eviews version 10.0 for data obtained from NISR CPI data

Outputs presented in table 8 above turn out essential to complement that the acceptance of the alternative hypothesis for the model 3 and the fact that the coefficient associated to the trend is significant leads us to conclude that we have a Difference Stationary (DS) process meaning that series contains stochastic trend, and need to integrated of order one, I(1), so that differencing yields a stationary series from which we are confident to formulate econometrical model explaining relationship with response variable that is food price.

In nutshell, all variables; food price, price of energy, price of education, price of health, price of transport, price of communication, exchange rate and GDP are not stationary at level meaning that any of their associations is spurious regression, however after being transformed into first difference they all become stationary that means that there is a possibility of long run equilibrium relationship and in following section of this research paper, it was discovered that variables have a long run relationships and disequilibrium manifested in short run was eliminated through error correction mechanism.

3.3. Relationships between Consumer Food Price and Factors Causing Food Price to Fluctuate in Rwanda

A regression of a nonstationary time series on another nonstationary time series may produce a spurious regression. We are going to analyze these relationships deeply to check both long run and short run relationships between variables.

3.3.1 Least squares regression

Table 9 shows that regression of food prices on explanatory variables; energy, education, health, transport, communication, exchange rate and GDP have produced a spurious regression. The symptom of spurious regression is that R2 is greater than Durbin-Watson statistic, in our case R2=0.924697 which is greater than Durbin-Watson=0.307069

Table 9: Least Squares Regression

Dependent Variable: LOGF
Method: Least Squares
Date: 02/03/19 Time: 14:04
Sample: 2009M02 2018M12
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGN	-0.715254	0.230957	-3.096919	0.0025
LOGE	0.072176	0.099339	0.726557	0.4690
LOGH	-0.278714	0.230437	-1.209505	0.2290
LOGT	-0.156305	0.295259	-0.529384	0.5976
LOGC	-0.654021	0.378855	-1.726308	0.0871
LOGX	1.134809	0.327787	3.462029	0.0008
LOGG	0.242032	0.201332	1.202152	0.2319
C	3.466788	1.473905	2.352110	0.0204

R-squared	0.924697	Mean dependent var	4.613589
Adjusted R-squared	0.919948	S.D. dependent var	0.195063
S.E. of regression	0.055190	Akaike info criterion	-2.891209
Sum squared resid	0.338099	Schwarz criterion	-2.704377
Log likelihood	180.0269	Hannan-Quinn criter.	-2.815343
F-statistic	194.7209	Durbin-Watson stat	0.307069
Prob(F-statistic)	0.000000		

Results of table 9 produce nonsensical or spurious results due to the fact that variables were not stationary. One way to guard against it is to verify if the time series are cointegrated. This cointegration analysis is indispensable to mitigate risk of estimating the regression of spurious relationships that would give fortuitous results due to correlation between the series affected by a stochastic trend and then interpreting the results in a flawed way.

3.3.2 Cointegration analysis

To understand what is the cointegration, let take this example, assume you there two drunks (i.e., two random walks) drifting around. The drunks don't know each other (that means they are independent), so there is no meaningful relationship between their paths. However, on the other if instead there is a drunk walking with his/her dog. This time there is a connection.

Simply, though each path individually is still an unpredictable random walk, given the location of one of the drunk or dog, we have a cute good idea of where the other is; that is, the distance between the two is fairly predictable. For instance, if the dog strolls too far away from the owner, it will tend to move in his/her direction to avoid losing him/her, so the two stay close together despite a tendency to stroll around on their own. This relationship of the drunk and his/her dog form a cointegrating regression. In our study, we want to find whether there is a long run relationship between food prices and explanatory variables that are energy, education, health, transport, communication, exchange rate and GDP.

The reason to choose using cointegration to establish relationship between our variables instead of using R squared or standard regression is that standard regression analysis fails when dealing with non-stationary variables which is our case, leading to spurious regressions that suggest relationships even when there are none. In addition, a cointegration analysis is chosen to help us to know whether analyses are going to be trailed from a Vector Error Correction Model (V-ECM) in the case of the Differency Stationary (DS) series or Vector Autoregressive Model (V-ARM) in the case of the Trend Stationary (TS) series marked with a determinist trend where the risk of cointegration does not present.Therefore, we are going to conduct a cointegration analysis to establish whether there is a long-run or equilibrium relationship between variables. Below are cointegration regression and cointegration test that leads to our results.

3.3.2.1.Cointegration regression

We say that there is cointegration between two or several time series if a long-run relationship exists between these series and it is then the result of the fact that the fluctuations of prices of predictors (energy, education, health, transport, communication, exchange rate and GDP) allow to predict the change of food price.

As a result, the analysis of a cointegration establishes a powerful tool that allows giving clear answers on the existence or non-stable and long-run linear relationship between different series of variables under study.

The estimation of long run model by fully modified least squares (FMOLS) by plugging empirical results derived from our study of analysis of factors affecting food price fluctuations in Rwanda for the data of period from 2009 to 2018 leads us to formulate the model as: LogFt=4.91-0.79LogNt+0.12LogEt-0.47LogHt-0.31LogTt-0.85LogCt+1.38LogXt+0.19LogGt+Ɛt

The coefficients R^2 and adjusted R^2 reveal that about 92% of the variation of food's prices in Rwanda is explained by the explanatory variables of the cointegrating model. Outputs of cointegration model are presented in table 10 below:

Table 10: Cointegration Regression

Dependent Variable: LOGF
Method: Fully Modified Least Squares (FMOLS)
Date: 02/03/19 Time: 14:09
Sample (adjusted): 2009M03 2018M12
Included observations: 118 after adjustments
Cointegrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGN	-0.793135	0.412443	-1.923014	0.0571
LOGE	0.115207	0.176034	0.654460	0.5142
LOGH	-0.471294	0.408558	-1.153555	0.2512
LOGT	-0.309123	0.531229	-0.581902	0.5618
LOGC	-0.849517	0.673106	-1.262084	0.2096
LOGX	1.377103	0.579711	2.375499	0.0193
LOGG	0.190557	0.356303	0.534818	0.5939
C	4.907244	2.605545	1.883385	0.0623

R-squared	0.921486	Mean dependent var	4.616121
Adjusted R-squared	0.916490	S.D. dependent var	0.193921
S.E. of regression	0.056040	Sum squared resid	0.345447
Long-run variance	0.009516		

3.3.2.2 Engle-Granger test

The simple test for cointegration adopted by the researcher is Engle-Granger (EG) or Augmented Engle-Granger (AEG) Test. In short, EG and AEG are simply DF and ADF on the residuals from the cointegrating regression. The analysis of results in table 11 at the significance level of 0.05 (5%), by regressing logarithm of food prices on logarithm of explanatory variables, and using DF or ADF test on the residuals of cointegrating regression which in this context is known as EG or AEG lead to reject the null hypothesis that residuals series has a unit root in favor of alternative hypothesis stating that residuals of cointegrating regression are stationary. It implies that there is a long run equilibrium relationship between response variable; food price and explanatory variables. We can now conclude the existence of a long-run and stable relation between series under study that are food price, energy, education, health, transport, communication, exchange rate and GDP.

Results in table 11 lead us to conclude that the risk that the regression is fallacious is discharged and thus, we can interpret the coefficients of this long-term relationship. Economic interpretation of results in table 10 is that the various products under study reflect very well a utility between them and are differently classified by the consumer.

In our case, as all series under study are expressed in logarithm, the interpretation of cointegrating coefficients are then in terms of elasticity that is a measure of responsiveness of a consumer to changes in prices. Let's know interpret the model:

LogFt=4.91-0.79LogNt+0.12LogEt-0.47LogHt-0.31LogTt
0.85LogCt+1.38LogXt+0.19LogGt+Ɛt

From the results presented in table 10 and model above we conclude that if there is a one percentage change in prices of energy there is 0.79 percentage change in prices of food, if there is a one percentage change in prices of education there is 0.12 percentage change in prices of food, if there is a one percentage change in prices of health there is 0.47 percentage change in prices of food, if there is a one percentage change in prices of transport there is 0.31 percentage change in prices of food, if there is a one percentage change in prices of communication there is 0.85 percentage change in prices of food, if there is a one percentage change in exchange rate there is 1.38 percentage change in prices and if there is a one percentage change in GDP there is 0.19 percentage change in prices of food. It is clearer that exchange rate causes significant fluctuations comparatively to other explanatory variables.

Table 11: Engle-Granger Test

Cointegration Test - Engle-Granger
Date: 02/03/19 Time: 14:12
Equation: UNTITLED
Specification: LOGF LOGN LOGE LOGH LOGT LOGC LOGX LOGG C
Cointegrating equation deterministics: C
Null hypothesis: Series are not cointegrated
Automatic lag specification (lag=1 based on Schwarz Info Criterion, maxlag=12)

	Value	Prob.*
Engle-Granger tau-statistic	-4.559432	0.2636
Engle-Granger z-statistic	-45.88039	0.0583

*MacKinnon (1996) p-values.

Intermediate Results:

Rho - 1	-0.215005
Rho S.E.	0.047156
Residual variance	0.000660
Long-run residual variance	0.002196
Number of lags	1
Number of observations	117
Number of stochastic trends**	8

**Number of stochastic trends in asymptotic distribution.

Engle-Granger Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Date: 02/03/19 Time: 14:12
Sample (adjusted): 2009M04 2018M12
Included observations: 117 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.215005	0.047156	-4.559432	0.0000
D(RESID(-1))	0.451714	0.083886	5.384881	0.0000

R-squared	0.249771	Mean dependent var	-0.001250
Adjusted R-squared	0.243247	S.D. dependent var	0.029537
S.E. of regression	0.025695	Akaike info criterion	-4.468110
Sum squared resid	0.075926	Schwarz criterion	-4.420893
Log likelihood	263.3844	Hannan-Quinn criter.	-4.448941
Durbin-Watson stat	1.873676		

3.3.2.3.Johansen cointegration test

The existence of one or several cointegrating relations between the series permits to conclude the existence of one or several stable and long-run relations between the series. That means that there is interdependence between the cointegrated series. The test of cointegration of Johansen is so important due to the fact that, in the multivariate analysis where it can come about that there is a presence of more than one vector of cointegration, the method of Engle-Granger is no longer valid because it is applicable only in the case of the existence of a single vector of cointegration.

The results of cointegration test of Johansen with an intercept are represented in the table 12 below.

Table 12: Johansen Cointegration Test

Date: 02/03/19 Time: 14:53
Sample (adjusted): 2009M07 2018M12
Included observations: 114 after adjustments
Trend assumption: Linear deterministic trend
Series: LOGF LOGN LOGE LOGH LOGT LOGC LOGX LOGG
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.519338	202.0140	159.5297	0.0000
At most 1	0.265445	118.4987	125.6154	0.1251
At most 2	0.251623	83.33082	95.75366	0.2621
At most 3	0.139160	50.28806	69.81889	0.6252
At most 4	0.103906	33.20554	47.85613	0.5455
At most 5	0.087220	20.69857	29.79707	0.3767
At most 6	0.068968	10.29494	15.49471	0.2587
At most 7	0.018668	2.148275	3.841466	0.1427

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.519338	83.51529	52.36261	0.0000
At most 1	0.265445	35.16787	46.23142	0.4493
At most 2	0.251623	33.04276	40.07757	0.2493
At most 3	0.139160	17.08251	33.87687	0.9186
At most 4	0.103906	12.50698	27.58434	0.9104
At most 5	0.087220	10.40363	21.13162	0.7061
At most 6	0.068968	8.146662	14.26460	0.3640
At most 7	0.018668	2.148275	3.841466	0.1427

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The analysis of results in table 12 reveals that at the significance level of 0.05 (5%), the first null hypothesis (r=0 with p-value=0.0000) stating that there is no cointegrated equations (it means no cointegration among eight variables) is convincingly rejected in favor of alternative hypothesis that at least exist one cointegrated equation and we failed to reject it in the case of r=1 with a p-value of 0.1251, which is superior to the fixed level of significance that is 5%, it means that eight variables move together in the long run. This conclusion is also confirmed by the trace test and the maximum eigenvalue Test. Therefore, our variables under study are stable and have long run relationship between them.

3.3.3 Error correction mechanism (ECM)

From cointegration analysis, we found that variables under our study are cointegrated; that is, there is a long run equilibrium relationship between them. Indeed, it means that in the short run there may be disequilibrium. Therefore, we can treat the error term in cointegration model as the "equilibrium error." And we can use this error term to tie the short-run behavior of consumer food price to its long-run value. An Error Correction Modeling helps to examine the presence of equilibrium or disequilibrium between short run dynamics and long run equilibrium.

Note that the procedure of differencing to achieve stationarity for analyzing the relationship between stationary variables leads in a loss of valuable long run information in the data. An error correction term in ECM, which combines both long run and short run behaviour of the variables, can thus rectify this problem as the information about the long run equilibrium relationship will be in the error correction term.

The estimate of negative error correction term in ECM elucidates the magnitude of disequilibrium to be eliminated at each period. Further, how quickly disequilibrium can be corrected or eliminated is subject to the size and statistical significance of constant estimate of error correction term. If the size is larger, then and there the proportion of error correction will be larger. Therefore, the coefficient of the error correction term is interpreted as the coefficient of speed of adjustment between short run dynamics and long run equilibrium values. In other words, coefficient of the error correction term measures the speed of movement towards a new equilibrium because of introduction of error correction term of the previous period as explanatory variable in ECM permits to move towards a new equilibrium.

Table 13: Error Correction Model

Dependent Variable: D(LOGF)
Method: Least Squares
Date: 02/03/19 Time: 23:55
Sample (adjusted): 2009M03 2018M12
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGN)	0.058980	0.234183	0.251853	0.8016
D(LOGE)	-0.138730	0.093575	-1.482556	0.1411
D(LOGH)	-0.134706	0.241159	-0.558577	0.5776
D(LOGT)	0.185175	0.225647	0.820644	0.4136
D(LOGC)	-0.355146	0.317496	-1.118584	0.2658
D(LOGX)	0.377535	0.729526	0.517507	0.6059
D(LOGG)	0.116002	0.137977	0.840741	0.4023
E(-1)	-0.114941	0.047834	-2.402912	0.0180
C	0.001700	0.003916	0.434227	0.6650

R-squared	0.114333	Mean dependent var	0.003849
Adjusted R-squared	0.049330	S.D. dependent var	0.027339
S.E. of regression	0.026656	Akaike info criterion	-4.338401
Sum squared resid	0.077449	Schwarz criterion	-4.127078
Log likelihood	264.9657	Hannan-Quinn criter.	-4.252597
F-statistic	1.758883	Durbin-Watson stat	1.167664
Prob(F-statistic)	0.093040		

Results in table 13 present coefficients of regression in short run. The estimation of coefficients shows undoubtedly that the Error Correction Model is well specified and hence the representation of error correction mechanism is validated. Also, the coefficient of the error term that explains the magnitude of disequilibrium to be eliminated at each period is significantly negative as expected. We can now write short run model as:

$$\Delta LogFt=0.0017+0.059\Delta LogNt-0.139\Delta LogEt-0.135\Delta LogHt+0.185\Delta LogTt-0.355\Delta LogCt+0.378\Delta LogXt+0.116\Delta LogGt-0.115\mathcal{E}_{t-1}+\mathcal{E}t$$

Where Δ denotes the first difference operator, $\mathcal{E}t$ is a random error term, and $\mathcal{E}_{t-1}$ is the one-period lagged value of the error from the cointegrating regression. The ECM then state that food price depends on prices of energy, education, health, transport, communication, exchange, GDP and also on equilibrium error term. If the equilibrium error term is nonzero, then the model is out of equilibrium. Since the coefficient of $\mathcal{E}_{t-1}$ is -0.115 it means that if $\mathcal{E}_{t-1}$ is positive, the term $-0.115\mathcal{E}t$ will be negative and food price is too high to be in equilibrium (above equilibrium value) and therefore, change in food price will be negative to restore the equilibrium. That is if food price is above its equilibrium value, it will start falling in the next month to correct the equilibrium error. By the same logic, if $\mathcal{E}t-1$ is negative; food price is below its equilibrium value, the term $-0.115\mathcal{E}t$ will be positive which will cause changes in food price to be positive, leading prices of food to rise in next month. Thus, the speed of adjustment between short run dynamics and long run equilibrium values is 0.115.

4. Conclusion

The main objective of this study was to analyze of factors affecting food price fluctuations in Rwanda. The study used a set of data for events occurred from 2009 – 2018 and also eviews version 10 was employed to analyze these time series data and econometric model was estimated and establishes relationship between food price and prices of energy, education, health, transport, communication, exchange rate and GDP.

Regarding individual behaviour of variables under study that are food price, prices of energy, education, health, transport, communication, exchange rate and GDP. Research results from Augmented Dickey Fuller Test revealed all series had a unit root and importantly after transforming into first difference they become stationary and then a stable and long run equilibrium relationship food price and prices of energy, education, health, transport, communication, exchange rate and GDP was confirmed by Johansen Cointegration Test.

About relationship between response variable (food price) and explanatory variable (prices of energy, education, health, transport, communication, exchange rate and GDP). Research confirms that variables are cointegrated and a cointegration regression yielded model explaining the magnitude at which changes in prices of energy, education, health, transport, communication, exchange rate and GDP affect changes in food price.

5. Recommendations

After reviewing coefficients and models for both long run and short run come out of this research, taking account relationships revealed between food prices and factors causing food price to fluctuate. Therefore, the researcher recommends the following point in order to support policy makers to mainly maintain food price stable and sustain economic growth and development.

Researcher recommends that government should put strong control on monetary policies, foreign exchange market and also on prices of various indispensable products such as fuel, water, electricity, transport, communication, transport, education and health to ensure prices remain in band whereby encouraging sellers and buyers in equilibrium for better welfare of all. Besides policies to reduce fluctuations and extreme price spikes, government should increase resilience of producers and consumers to deal with price changes. This can be done by supporting contract farming and price insurance mechanisms on the production side and by improving access to financial services on the consumer side.

Additionally, improving the market information base would further help all market actors to form expectations based on fundamentals and to detect shortages early.

Based on finding that variation of prices of energy has effects in fluctuation of food price, researcher recommend that designing flexible energy policies that are responsive to the food supply situation can also help stabilize prices and reduce volatility spillovers from oil and electricity markets in times of food crisis.

Researcher strongly recommends other researchers to deepen the research on this subject matter to increase the evidence base by expanding time and adding more variables that would be beneficial to explore more on subject matter

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