**Rwanda Journal ISSN 2305-2678 (Print); ISSN 2305-5944 (Online)**
DOI: http://dx.doi.org/10.4314/rj.v2i1.3B

# Food Prices Transmission In Rwanda: Econometric Analysis

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***Abstract***

*This paper analyses the food prices transmission using econometric techniques where vector autoregressive models were formulated. Price transmission means the change of one price caused by the change of another price. Spatial price transmission is used in this study and price transmission is affected by different factors; among them we have transport and transaction costs and market power. Monthly average prices data of potatoes and banana collected from Musanze, Huye, Kibungo, Muhanga and Nyabugogo markets from January 2002 to July 2013 are used.*

*Potatoes are mainly produced in Musanze District and Banana in Ngoma District where the Kibungo market is located. Analysis was conducted in two ways, first concerns relationship between retail prices of potatoes in Musanze market and retail prices of the other markets and second on relationship between retail prices of banana in Kibungo market and retail prices of banana of other markets. Graphical analysis shows that there is a positive trend for all retail prices. Retail prices of all markets are not stationary at levels but the first differences are stationary. This implies that series are integrated of order one [I(1)]. Engle and Granger co-integration tests were done and the results show that the variables are co-integrated. This implies that there is a long run relationship.*

*Results of Error Correction Model (ECM) show that the coefficient of error term is significant in all models. This implies that there is a short-run relationship. Granger causality tests confirm the existence of causality between analyzed variables. These results provide useful information for forecasting the retail prices of potatoes and banana in different markets.*

***Keywords:*** *Price transmission, Granger Causality; Co-integration; Vector Autoregression (VAR) and Error Correction Model (ECM).*

## 1. Introduction

Price signals are transmitted spatially and vertically between countries or regions. When a change in one price causes another price to change there is a price transmission. Price transmission measures the effect of change in one price on another price. Price transmission analysis uses price data to measure various aspects of the relationship between the retail prices in two markets. In price transmission analysis they use price data from at least two different markets and it is important to have monthly data for different years.

Analysis of price transmission is very important for three principal reasons, first to study the relationship between world prices and local prices for a given commodity, local prices for the same commodity in different cities, prices of two related commodities in the same market channel and prices of two competing commodities; second to identify poorly functioning markets, and finally to forecast prices based on trends in related prices.

For the current study, spatial price transmission is considered, since the retail prices of foods markets are from different markets. Retail prices of potatoes and banana from Musanze, Huye, Muhanga, Nyabugogo and Kibungo markets are analyzed.

The general objective of this study is to conduct an analysis of spatial food price transmission in Rwanda. The specific objectives are to:

1. Examine trend of potatoes and banana from Musanze, Huye, Muhanga, Nyabugogo and Kibungo markets;
2. Examine existence of short and long run relationship between retail prices of potatoes in Musanze market and retail prices of potatoes of other markets;
3. Examine existence of short and long run relationship between retail prices of banana in Kibungo market and retail prices of banana of other markets;
4. Investigate existence of Granger causality between retail prices of potatoes in Musanze market and retail prices of potatoes of other markets;
5. Investigate existence of Granger causality between retail prices of banana in Kibungo market and retail prices of banana of other markets.

The following sections presents theoretical context of the study, methodology, results and conclusion.

## 2. Theoretical context of the Study

Price transmission is affected by different factors, among them we have transport and transaction costs, market power, increasing returns to scale in production, product homogeneity and differentiation, exchange rates and border and domestic policies (Conforti, 2004).

In economic theory a price reduction at the producer level is slowly transmitted to the final consumer while price increases is quickly transmitted to the final consumer. Vavra et al. (2005) show that the implication of this asymmetry in price transmission, if it exists, is that an analysis of trade liberalisation likely over-estimates the benefits to consumers in countries that have gone through policy reform, because the reduction in farm prices might not be immediately or fully transmitted to final consumers.

Keats et al. (2010) found that if markets are efficient and policies are not an obstacle to their operation, changes in the world price of any given commodity should be similarly reflected in changes in domestic prices – phenomenon known as ‘price transmission’. In many poor countries, the recent increases in prices of staple foods have raised the real incomes of those selling food, many of whom are relatively poor, while hurting net food consumers, many of whom are also relatively poor (Ivanic & Martin, 2008).

There are three types of price transmission:

- Spatial price transmission happens when a commodity is heavily traded between two regions or countries. For example, banana prices in the country/region that exports it strongly affect the price of the banana in the importing country/region.
- Vertical price transmission happens when the price of a good rises due to the rising price of one of the inputs used to make it.
- Cross-commodity price transmission happens when the price of a good which may be substituted for another good may affect the price of the other good.

Different studies have been conducted on price transmission using spatial approach (Getnet et al., 2005; Minot, 2011; Conforti, 2004), or vertical approach (Vavra & Goodwin, 2005; Goodwin, 2006; Conforti, 2004; Popovics & Tóth, 2005).
The common methods used in analysis of price transmission are Ratio of percentage changes, Correlation coefficient, Regression analysis and Co-integration analysis. Ratio of percentage analyse the change between two time periods. This method is limited because it doesn’t analyse all periods or take into account the trend of series. Correlation coefficient gives the degree of interrelationship between two variables by calculating Pearson correlation coefficient (r) and coefficient of determination ($R^2$). Regression analysis is used after model specification and discussion on the model which fits in order to estimate dependant variable. Co-integration analyses the long run relationship between two series.

## 3. Methodology

Data used are obtained from the Ministry of Agriculture and Animal Resources and data are collected daily in different markets. Monthly average retail prices of potatoes and banana observed in Musanze, Kibungo, Huye, Nyabugogo and Muhanga from January 2002 to July 2013 are used and all data are reported in Rwandan francs.

The total observations used in analysis are 139. Variables used in this study are: Retail Prices of Potatoes in Musanze Market (PPMuM), Retail Prices of Potatoes in Huye Market (PPHM), Retail Prices of Potatoes in Muhanga Market (PPMM), Retail Prices of Potatoes in Kibungo Market (PPKM Retail Prices of Potatoes in Nyabugogo Market (PPNM) for potatoes, Retail Prices of Banana in Kibungo Market (PBKM), Retail Prices of Banana in Huye Market (PBHM), Retail Prices of Banana in Muhanga Market (PBMM), Retail Prices of Banana in Musanze Market (PBMuM) and Retail PBKM and Prices of Banana in Nyabugogo Market (PBNM) for banana.

After transformation of retail prices of all variables in logarithm in order to reduce data variability. This study uses econometrics techniques in analysis of food price transmission i.e. test of unit root for stationarity, co-integration tests, error correction model estimation and Granger causality tests.

In Rwanda, among those markets Musanze is the main producer of potatoes and Kibungo for Banana. The price of potatoes is analysed using one side, Musanze, as producer and price of potatoes on the other side i.e. Huye, Nyabugogo, Muhanga and Kibungo. The price of banana is analysed using one side, Kibungo, as producer and price of banana on the other side i.e. Huye, Nyabugogo, Muhanga and Musanze. Eight bivariate models are formulated, four for potatoes and four for banana retail prices. The general bivariate vector autoregressive (VAR) model used is:

$$Y_t = ¤ + ¢\, Y_{t-i} + ¬_t$$

**(1)**

Where:

$$Y_t = \begin{bmatrix} PMa_t \\ PMb_t \end{bmatrix};\; Y_{t-i} = \begin{bmatrix} PMa_{t-1} \\ . \\ . \\ . \\ PMa_{t-p} \\ PMb_{t-1} \\ . \\ . \\ . \\ PMb_{t-q} \end{bmatrix};\; ¤ = \begin{bmatrix} ¤_1 \\ ¤_2 \end{bmatrix};\; ¢ = \begin{bmatrix} \sim_{11} & \sim_{12} \cdots & \sim_{1p} & {}_{11} & {}_{12} \cdots & {}_{1q} \\ \sim_{21} & \sim_{22} \cdots & \sim_{2p} & {}_{21} & {}_{22} \cdots & {}_{2q} \end{bmatrix} \text{ and } ¬_t = \begin{bmatrix} £_{1t} \\ £_{2t} \end{bmatrix}$$

¤ and ¢ are parameters, $Y$ and $X$ are series. $t(t = 1, 2, ..., T)$ is time period and $p$ and $q$ represents lags for $PMa$ and $PMb$. $PMa$ represents the retail prices of Potatoes or banana in Market *a* and $PMb$ represents the retail prices of Potatoes or banana in Market *b*.

$\pounds_{1t}$ and $\pounds_{2t}$ are the stochastic error terms with the following assumptions:

$$(i)\ E(\pounds_{1t}) = E(\pounds_{2t}) = 0$$

$$(ii)\ E(\pounds_{1t}\pounds_{2t}) = \begin{pmatrix} \mathrm{var}(\pounds_{1t}) & \mathrm{cov}(\pounds_{1t}\pounds_{2t}) \\ \mathrm{cov}(\pounds_{1t}u_{2t}) & \mathrm{var}(\pounds_{2t}) \end{pmatrix} = \begin{pmatrix} \pm_1{}^2 & 0 \\ 0 & \pm_2{}^2 \end{pmatrix}$$

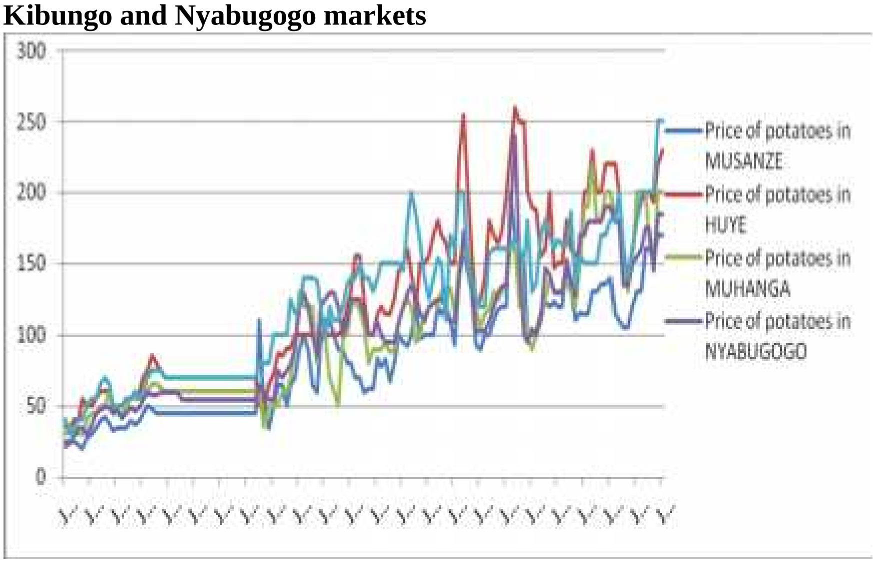
## 4. Results and Discussions

This section gives graphical and econometric analysis of retail prices of potatoes and banana in Musanze, Kibungo, Huye, Nyabugogo and Muhanga markets.

### 4.1. Graphical analysis of retail prices of potatoes and banana

Graphical analysis was done in order to have a feel of the data used in this study. Retail prices of potatoes for Musanze, Huye, Muhanga, Kibungo and Nyabugogo are graphically represented in Figure 1. The results show the prices of potatoes have fluctuated especially from September 2005 and there has been an upward trend of retail prices of potatoes in all markets. Price of potatoes has increased more than 6 times in all markets between January 2002 and July 2013. This increment has negative effect on purchase power of consumers.

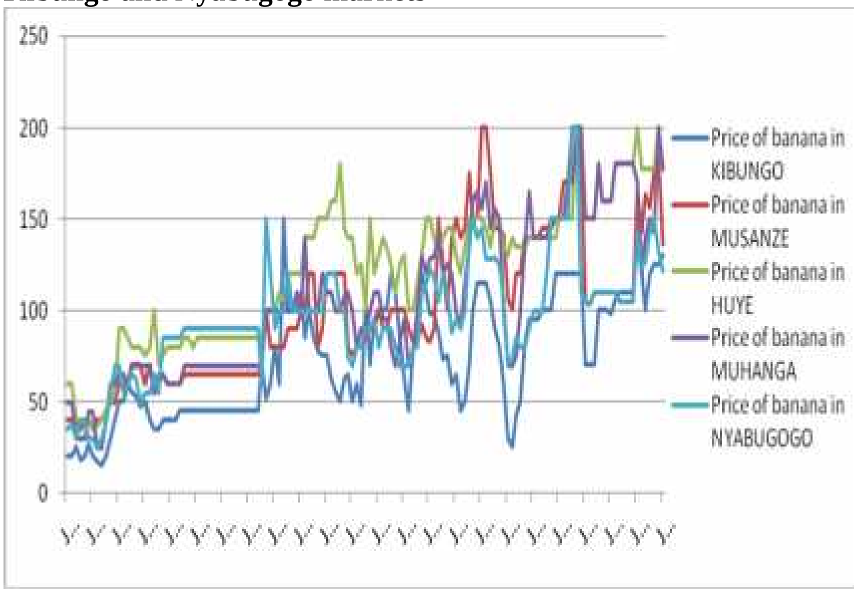
**Figure 1 Retail prices of potatoes in Musanze, Huye, Muhanga, Kibungo and Nyabugogo markets**




*Source: MINAGRI, 2013.*

The prices of banana are represented in Figure 2. The prices of banana are lowest in Kibungo markets. There are big fluctuations, in all markets, from September 2005 and there is an upward trend.

**Figure 2 Retail prices of banana in Musanze, Huye, Muhanga, Kibungo and Nyabugogo markets**




*Source: MINAGRI, 2013.*

Figure 1 shows that prices of potatoes and banana in different markets follow very similar patterns while Figure 2 indicates that prices of banana in different markets follow also very similar patterns. This implies important price transmission processes across analyzed markets in Rwanda. Increases of prices are explained by low growth production and high demand. These increases reduce purchase power of food buyers and especially poor households will have to spend an even higher share of their limited income on food. Policies that encourage increase of production are very urgent to stabilize the prices.

### 4.2. Econometric analysis of retail prices of potatoes and banana

This section, related to econometric analysis, has started by transforming all retail prices series in logarithm in order to reduce data variability. In this section, test of unit root for stationarity, Co-integration tests, Error Correction Model estimation and Granger causality tests are conducted.

#### 4.2.1 Test of stationarity

Before analysis of time series data you need to test if series are stationary or not. Regression analysis conducted using non-stationary series may give misleading results i.e. regression analysis may indicate that the coefficient is a statistically significant even when there is no relationship. As different tests can be used to test stationarity, in this study we have adopted for Augmented Dickey-Fuller (ADF) tests. There are two foods, banana and potatoes, and prices were collected from five markets i.e. Huye, Kibungo, Muhanga, Musanze and Nyabugogo.

Augmented Dickey-Fuller (ADF) tests were used in order to test the stationarity of the prices of banana in Huye, Kibungo, Muhanga, Musanze and Nyabugogo markets and results of unit root tests are presented in Table 1.

**Table 1 Unit root tests of prices of banana on levels and first differences**

| Series | Critical value at 5% | ADF test statistic | Prob. |
|---|---|---|---|
| **SERIES AT LEVELS** | | | |
| Prices of Banana in Huye Market (PBHM) | -1.943157 | 0.678079 | 0.8611 |
| Prices of Banana in Kibungo Market (PBKM) | -1.943157 | 0.366127 | 0.7889 |
| Prices of Banana in Muhanga Market (PBMM) | -1.943157 | 0.472097 | 0.8156 |
| Prices of Banana in Musanze Market (PBMuM) | -1.943157 | 0.547040 | 0.8331 |
| Prices of Banana in Nyabugogo Market (PBNM) | -1.943157 | 0.386748 | 0.7943 |
| **SERIES FIRST DIFFERENCES** | | | |
| Prices of Banana in Huye Market (PBHM) | -1.943175 | -13.67296* | 0.0000* |
| Prices of Banana in Kibungo Market (PBKM) | -1.943175 | -12.78260* | 0.0000* |
| Prices of Banana in Muhanga Market (PBMM) | -1.943175 | -11.01074* | 0.0000* |
| Prices of Banana in Musanze Market (PBMuM) | -1.943193 | -10.63588* | 0.0000* |
| Prices of Banana in Nyabugogo Market (PBNM) | -1.943175 | -13.30792* | 0.0000* |

* denote the significance at 5 percent.

The results for PBHM, PBKM, PBMM, PBMuM and PBNM at levels presented in Table 1 show that the null hypothesis of existence of unit root is not rejected since the Augmented Dickey-Fuller (ADF) test statistics are higher than the critical values at 5% significant level. All those series are not stationary at levels. The first differences of PBHM, PBKM, PBMM, PBMuM and PBNM are stationary. This implies that series are integrated of order one [I(1)]. In this analysis the prices of banana from Kibungo market are analyzed in comparison to other markets. The tests for unit roots using Phillips-Perron tests arrive at the similar conclusions.

Results of stationarity tests of prices of potatoes in different markets are presented in Table 2.

**Table 2 Unit root tests of prices of potatoes in levels and first differences**

| Series | Critical value at 5% | ADF test statistic | Prob. |
|---|---|---|---|
| **SERIES AT LEVELS** | | | |
| Prices of Potatoes in Huye Market (PPHM) | -1.943157 | 1.164326 | 0.9367 |
| Prices of Potatoes in Kibungo Market (PPKM) | -1.943157 | 1.159535 | 0.9362 |
| Prices of Potatoes in Muhanga Market (PPMM) | -1.943157 | 0.833825 | 0.8900 |
| Prices of Potatoes in Musanze Market (PPMuM) | -1.943157 | 0.672288 | 0.8600 |
| Prices of Potatoes in Nyabugogo Market (PPNM) | -1.943157 | 1.179953 | 0.9385 |
| **SERIES FIRST DIFFERENCES** | | | |
| Prices of Potatoes in Huye Market (PPHM) | -1.943175 | -10.01613* | 0.0000* |
| Prices of Potatoes in Kibungo Market (PPKM) | -1.943175 | -13.56215* | 0.0000* |
| Prices of Potatoes in Muhanga Market (PPMM) | -1.943175 | -12.41714* | 0.0000* |
| Prices of Potatoes in Musanze Market (PPMuM) | -1.943193 | -11.32568* | 0.0000* |
| Prices of Potatoes in Nyabugogo Market (PPNM) | -1.943193 | -10.09180* | 0.0000* |

* denote the significance at 5 percent.

Table 2 shows that PPHM, PPKM, PPMM, PPMuM and PPNM are not stationary at levels but all first differences are stationary. This implies that the series of prices of potatoes in Musanze market and series of other markets are integrated of order one [I(1)].

### 4.2.2 Co-integration tests

Co-integration tests help to determine the existence of long-run equilibrium relationship between variables. Variables $y_t$ and $x_t$ are co-integrated if residuals ($\hat{u}_t$) are integrated of order zero [I(0)]. Otherwise regression is spurious. There are different ways used to test co-integration. In this study we have used Engle and Granger co-integration test. Engle and Granger co-integration test is carried out in two steps:

1. Run the OLS regression of $y_t$ and $x_t$ presented in following equation:

$$y_t = \quad {}' x_t + u_t \qquad \textbf{(2)}$$

Where $x_t = (x_{1t}, x_{2t}, ...., x_{kt},)'$ represents the k-dimensional I(1) regressors.

After estimation of equation (2) we obtain the residuals $\hat{u}_t$ .

2. Apply a unit root test to $\hat{u}_t$ by constructing an autoregressive one (AR (1)) regression for $\hat{u}_t$ :

$$\hat{u}_t = \text{¯}\hat{u}_{t-1} + \text{£}_t \quad \textbf{(3)}$$

The null hypothesis is $H_0 : \text{¯} = 1$, this is the test of no-cointegration, because the null hypothesis of unit root in $\hat{u}_t$ implies that there is no-cointegration between y and x. So if you reject $H_0 : \text{¯} = 1$ in equation (3), you may conclude that there is a cointegration and vice versa.

The co-integration tests were used, according to Engle and Granger cointegration test, to analyse the long run relationship between PPMum and PPHM, PPMum and PPMM, PPMum and PPKM and PPMum and PPNM for potatoes and PBKM and PBHM, PBKM and PBMM, PBKM and PBMum PBKM and PBKM and PBNM for banana and the results show that the variables, analyzed in different models, are co-integrated. This implies that there is a long run relationship among analysed variables.

### 4.2.3 Error correction model

The co-integration regression presented in previous sub-section was limited to the analysis of the long-run relationship and does not deal with the short-run dynamics explicitly. Long-run relationship measures any relation between the levels of the variables under consideration while the short-run dynamics measure any dynamic adjustments between the first-differences of the variables. Error Correction Model (ECM) gives estimates of long-run transmission, short-run transmission and speed of adjustment to long-run equilibrium.
ECM is simply defined as:

$$\Delta y_t = \text{~}\text{£}_{t-1} + \text{¥}\Delta x_t + u_t \quad \textbf{(4)}$$

where $u_t$ is independent and identically distributed (i.i.d.).

Coefficient presented in equation (2) is called the long-run parameter while ~ and ¥ given in equation (4) are called short-run parameters. The ECM has both long-run and short-run properties; the first is in the error correction term $\text{£}_{t-1}$ and the second in the error correction coefficient ~ .

Results show that the coefficient of error term is significant in all models. This implies that there is a short-run relationship between analyzed variables. All the variables used in the ECM are stationary, and therefore, the ECM has no spurious regression problem.

### 4.2.4 Test of causality

Hamilton (1994) shows that Granger-causality tests are used to investigate if a scalar "$y$" can help in forecasting of another scalar "$x$".

If it doesn't, then we say that $y$ does not Granger cause "$x$". In other words, "$y$" does not help in predicting "$x$". In Granger-causality analysis there are three cases unidirectional causality, bilateral or bi-directional causality and absence of causality or independence of series.
Granger causality tests of retail prices of potatoes between Musanze market and other markets conducted in this study give the following conclusions:

1. The results of Granger causality tests of retail prices of potatoes in Musanze and Huye market show that there is a bi-directional causality between PPMuM and PPHM up to lag 9.
2. Granger causality tests of PPMuM and PPKM show there is a bi-directional causality up to lag 5 for causality from PPKM to PPMuM and lag one for PPMuM to PPKM.
3. Granger causality tests of prices of potatoes in Musanze and MUHANGA markets show that there is bi-directional causality for critical value of 10% level of significance.
4. Granger causality tests of prices of PPMuM and PPNM show that there is bi-directional causality.

   Granger causality tests of retail prices of banana between Kibungo market and other markets show that:

1. Granger causality tests show that there is bi-directional causality between PBKM and PBHM.
2. There is bi-directional causality between PBKM and PBMuM according to Granger causality tests.
3. Granger causality tests of prices of potatoes in Kibungo and MUHANGA markets show that there is bi-directional causality.
4. There is bi-directional Granger causality between PBKM and PBNM.

These results indicate bi-directional causality between PPMuM and PPHM, PPMuM and PPKM, PPMuM and PPMM, PPMuM and PPNM for potatoes and PBKM and PBHM, PBKM and PBMUM, PBKM and PBMUM, PBKM and PBMM for banana. Granger causality results of potatoes and banana, discussed above, provide useful information for policy recommendations and can be used in forecasting. Bi-directional causality certifies that the change of prices in one market has direct effect on another market and vice versa. This can be explained for the case of Rwanda by cost of transport which is very small due to the distance between markets analysed.

## 5. Conclusion

Spatial price transmission analysis in Rwanda is analysed using econometric techniques where eight bivariate models were formulated. Monthly data of retail prices of Potatoes and banana collected from Musanze, Huye, Kibungo, Muhanga and Nyabogogo markets are used. The results show that all series are not stationary at levels but first differences are stationary. The series are co-integrated which means that there is a long run relationship between series. Short-run relationship was analysed using error correction model and we found that there is a short run relationship. Granger causality tests show that there is bi-directional causality between PPMum and PPHM, PPMum and PPMM, PPMum and PPKM and PPMum and PPNM, PBKM and PBHM, PBKM and PBMM, PBKM and PBMum PBKM and PBKM and PBNM. The change of prices in one market has direct effect to other market. This can be explained by the distance which is less than 200 kms in many markets analysed and communication helps to know the prices of food in other markets. Policy makers and other economic operators can use these results in forecasting the retail prices of potatoes and banana in different markets.

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