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**Impact of Market Information System (E-Soko) on Beans Markets Integration:
Case of Rwanda**

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*Selected Paper prepared for presentation at the Southern Agricultural Economics
Association Annual Meeting, Orlando, FL, February 2- 5, 2013*

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Impact of Market Information System (E-Soko) on Beans Markets Integration: Case of Rwanda

Introduction

The agricultural sector is the backbone of the Rwandan economy. It averaged 45% of the GDP in the decade of 1995-2004 and generated nearly 75% of the foreign exchange earnings (PADAB, 2006). The sector employs 90% of the active population and Rwanda has nearly 1.4 million farming families. Among other crops grown in the country beans come to a second place in terms of land share after the banana crop, occupying about 30% of the total cultivated area and is grown by about 95% of population (ATDT/CIAT, 2002). Beans are grown alone or intercropped with banana, maize, tubers and sorghum. According to Beebe and McClafferty (2006) *Phaseolus Vulgaris* (Common Bean) is the world's most important food legume surpassing chickpeas, faba beans, lentils and cowpea. For more than 300 million people in the world, a bowl of beans constitutes an important part of their daily diet.

Beans are a key element in the diet for the majority of the Rwandan population. They constitute the principal source of protein and calories providing about 60% and 30% of all proteins and calories intake respectively (ATDT/CIAT, 2002). In fact, Rwandan people like many in the developing world where the consumption of proteins from animal sources (meat, eggs and fish) is rare and less affordable, gets mainly their proteins from beans and other legumes. Beans are a major staple food crop in Rwanda. The country has the world's highest bean per capita consumption estimated at 0.919kg (Kalyebara and Buruchara, 2008). Households on average consume 197kg of beans per year implying that the average per capita consumption is 38 kg of beans per person per year from beans produced by a household of six people (Kalyebara and Buruchara, 2008; ATDT/CIAT, 2002). Beans also supply B-vitamins, calcium, iron, phosphorous, potassium and zinc, which are essential for human growth, health and cognitive development.

Several reasons have motivated us to study the beans market in Rwanda. First, despite the importance of beans in the daily diet, the increasing demand for beans in Rwanda is not matching the supplied quantity. The increase in bean output has lagged behind the rise in population; this has led to a decline in per capita output from about 49 kg in 1989 to 27 kg in 2000, representing a reduction of about 50% (Mugabo and Kalyeraba, 2006). Consequently the demand for beans is significantly higher than supply, making Rwanda a net importer of beans. Second beans trade in Rwanda where the demand is high and the supply in decline constitute a potential of income generation for farmers. It is estimated that in 1990, 16% of beans produced were traded while in 2000, about 74% of total the beans produced (148,000 metric tons) were traded and generated a total income of 30 million US\$ (Rubyogo, 2004). These figures are supported by a survey by the Department of Agricultural Statistics in the Rwandan Ministry of Agriculture which shows that rural purchases were about 76,000 metric tons in 1990 compared to 120,000 metric tons of 2000 representing an increase of about 58%. The survey concludes that the increase in population, urbanization and disposable income will see a sustained growth in the beans trade in coming years. Third, to overcome the problem of satisfying the increasing demand in beans consumption, there is a need to improve the marketing channels of beans in Rwanda. One way to achieve this objective is to improve the price information dissemination to all economic agents involved in this sub-sector to make the production and consumption of beans more efficient.

Extensive literature on beans production especially in breeding and disease resistance has been produced mainly by the Rwanda Institute for Agricultural Research (ISAR) in collaboration with several international research centers such as CIAT. A

study by ECABREN (Eastern and Central Africa Bean Research Network) showed that bean farmers in the region were not producing necessarily for subsistence consumption but for local and regional markets (Kimani, 2004). Several market studies in the region reported that, for instance, Uganda and Tanzania enjoying low cost bean production are in a good position to increase exports of beans to Kenya and Rwanda. However, not as much research has been done on marketing, trade and price formation for beans, leaving a gap in the analysis of the bean sub-sector in Rwanda. In order to answer some of the above concerns, this paper will analyze the impact of a newly introduced market information system “E-Soko” on beans markets integration by comparing the period before and after the system. The rest of the paper is divided into the following sections. Section two offers a brief background on beans marketing and price information. Section three discusses the econometric model and methods. Section four presents the results and discussion and the last section concludes the study.

Background on beans marketing and price information dissemination

Beans, both bush and climbing, are the most important traded crop in rural areas of Rwanda, and third most important in urban areas in terms of value (USAID, 2010). However, despite the importance of beans in Rwanda, their production and trade do not have any organized structure as compared to almost all other staple crop value chains in Rwanda. Beans are cropped twice per year, with an average annual production of approximately 238,000 MT.⁸ Production increased following a decline in 2004-2005, with the area under bean cultivation increasing to 360,000 ha in 2007. The most significant increase in production occurred in the eastern districts of Rwanda (USAID, 2010 citing FAOSTAT 2009). However, despite the importance of beans in Rwanda, several barriers remain to get to a full development of the sub-sector that can respond

adequately to the growing beans demand. The constraints in the beans sub-sector are of two types: institutional and market (ATDT/CIAT, 2002). The marketing barriers concern mainly the finance and the price information. The beans production system is funded by small scale producers with limited resources in Rwanda; so far the private sector has been very slow to join in. Before 2008 price information was acquired through traders; there was no official entity that was collecting and disseminating price information. In a study by ATDT/CIAT (2002), beans traders and farmers mentioned that despite the existence of a project collecting price information on markets the information does not reach the traders and farmers. There is a lack of an organized and systematic method for collecting and disseminating market information to different stakeholders (USAID, 2009).

Generally in developing countries, reliable and timely market information can be accessed through market information systems (MIS) which most of the time are financially supported by donors (Kizito, 2009). Market information systems are designed to improve market transparency by disseminating information to producers, traders, processors, consumers, and policy makers to support them in their decision making process and reduce risks (Kizito, 2009; Pavanello, 2010). However in the last few years the Rwanda government through the Ministry of Agriculture has put into place a solid MIS that would provide accurate and timely price information to farmers, traders and the general public (consumers). With the help of some organizations such FOODNET and governments under the European Union price market information are disseminated through radio and posted on MINAGRI website (Ministry of Agriculture and Animal Resources) but this still has a very limited accessibility for the rural farmers (UNCTAD, 2008; USDA, 2009).

Among other achievements in using the information technology to disseminate agricultural information is the creation of E-Soko which is an e-market to help farmers market their agricultural products and get premiums prices (Balancing Act, 2010). The e-market is an electronic platform that allows farmers, consumers and traders to get up-to-date market price information by SMS. More recently (June 2010) an agricultural information and communication center (CICA) within the Ministry of Agriculture was launched to support the agricultural extension system to collect, process, produce disseminate and store agricultural information (MINAGRI website). In brief the market information system for agricultural products is in the process of being strengthened and expanded to embrace the use of modern technologies in order to disseminate market information more rapidly and to a wide audience of people.

Information is crucial to the analysis of a wide range of phenomena and is a central part of the foundations of economic analysis (Stiglitz, 1985). In studying the role of information in market prices, Stigler (1961) observed that price dispersion is a sign of market ignorance. Markets and advertising can, however, reduce the price gap between and among markets. Rashid et al. (2010) points out that the existence of price dispersion is a natural phenomenon for markets because it provides the incentives for market actors to trade. However it is the non-variability or the excessive variability of prices between locations that should be of a concern. Several studies have been carried out to study the spatial equilibrium of commodities prices among markets or commodity market integration. Baulch (1997) argues that the producers and consumers of agricultural products will not reap the benefits from market liberalization policies in the absence of

market integration. A number of those studies were conducted in Sub-Saharan Africa (SSA) region (see Rashid et al., 2010).

Data

The data used in the analysis were provided by the Department of Statistics in the Rwandan Ministry of Agriculture which collects commodity price at more than 30 markets around the country on 30 different traded commodities. Two datasets representing two periods were selected for this study: one dataset from 1999 to 2003 before the introduction of E-Soko market information system and another dataset from 2007 to 2012 during and after the introduction of E-Soko market information system (Figures 1 and 2). In each period eight markets were analyzed and each market represents a district (has a district name instead of its actual name). Those markets are Gatsibo and Ngoma in Eastern province, Rubavu and Nyamasheke in the Western Province, Musanze in Northern Province, Huye and Nyamagabe in Southern Province, and Kigali in the capital city for the 1999-2003 period. The same markets and districts were considered for the 2007-2012 except for the markets of Gakenke in Northern province, Nyagatare and Kirehe in the Eastern province (Figure 3). The markets were chosen to represent both the different provinces of the country and the high, medium and low beans production regions. The 1999-2003 and 2007-2012 datasets are both bi-weekly data collected by the Ministry of Agriculture agents on markets across the country. The data are prices in Rwandan Francs paid per kilogram of dried beans (equivalent to 2.204 pounds).

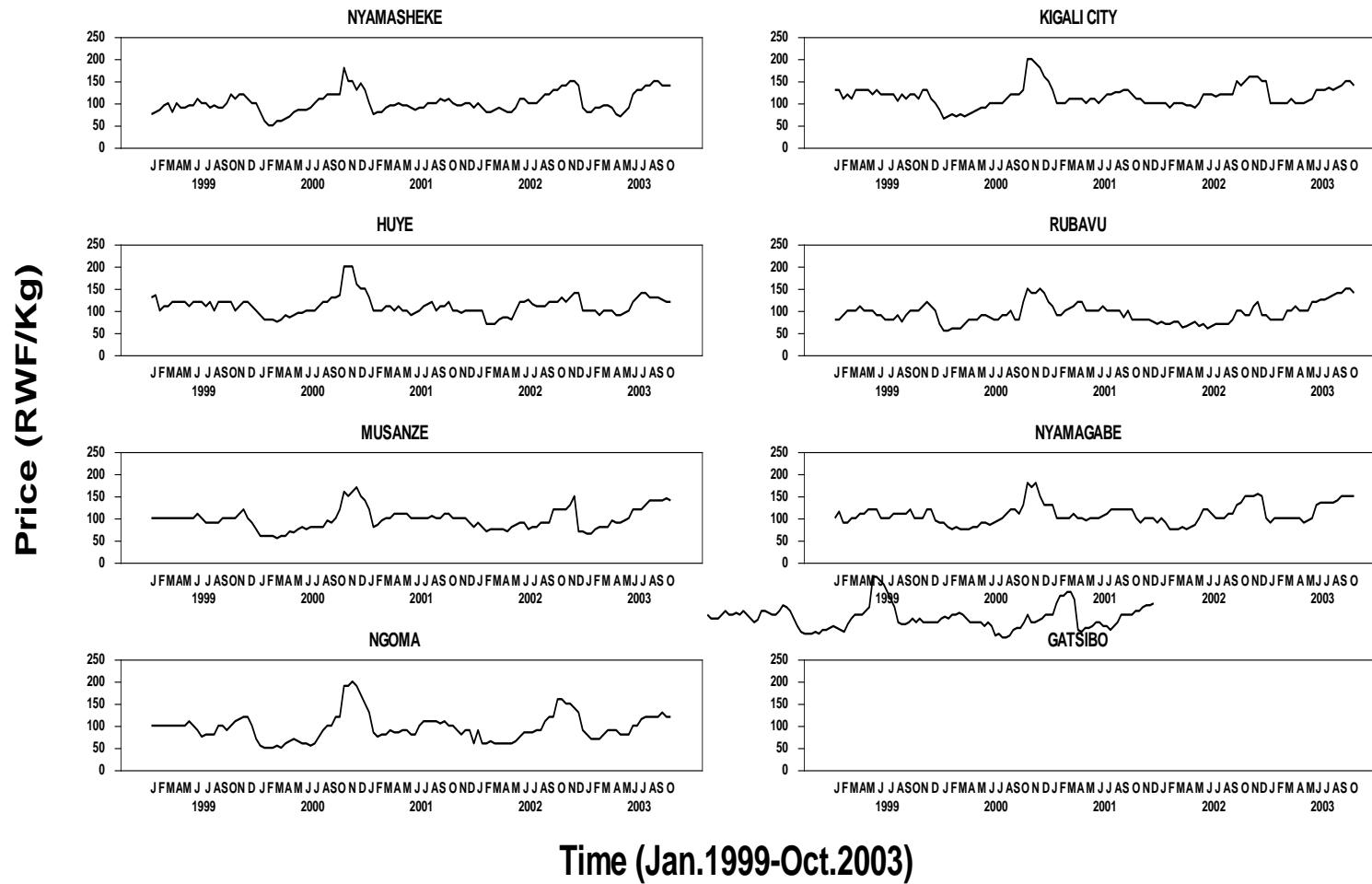


Figure 1. Price series in levels for eight beans markets in Rwanda, 1999-2003

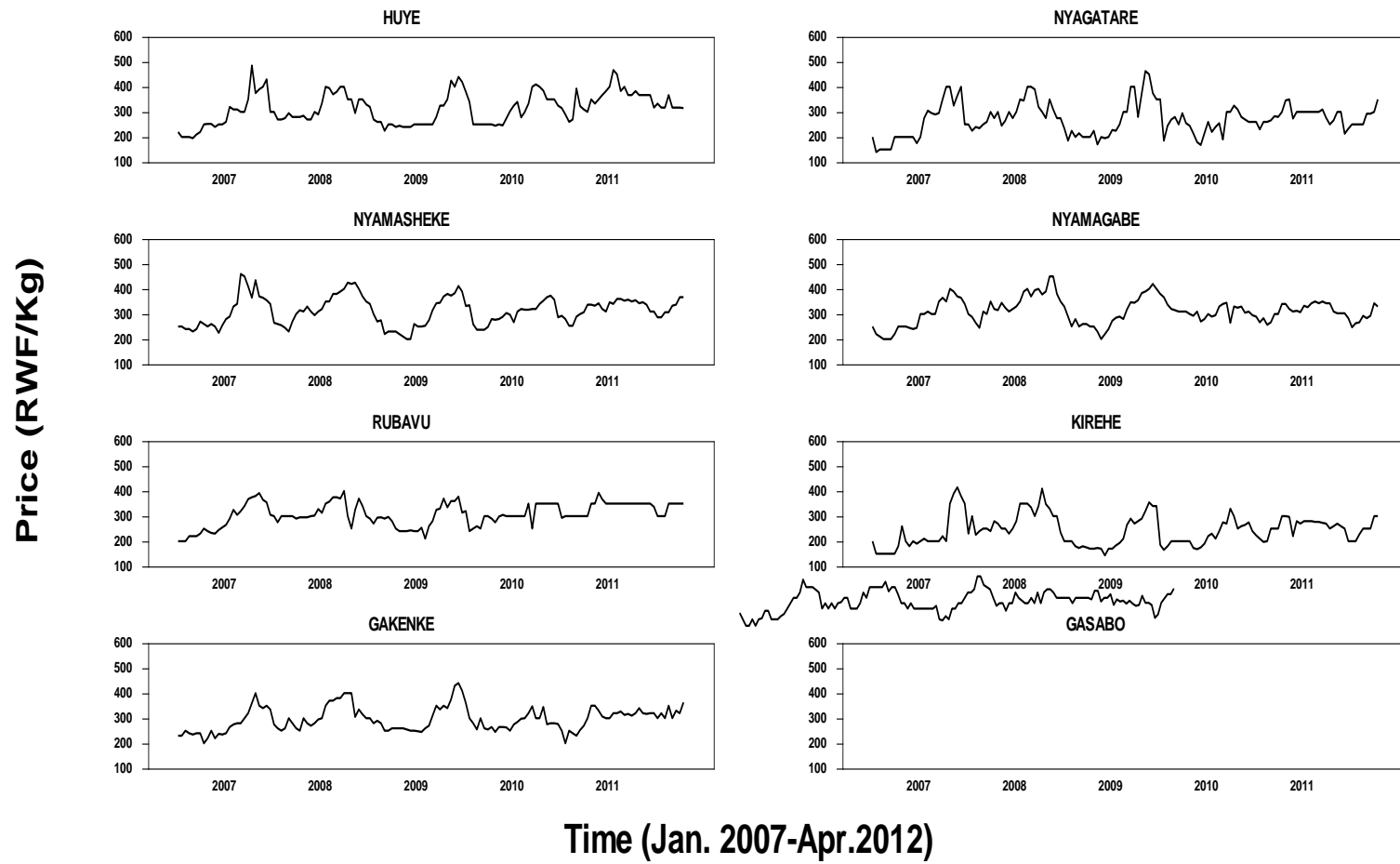
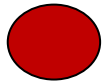
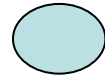


Figure 2. Price series in levels for eight beans markets in Rwanda, 2007-2012



Markets selected for the period of 1999-2003
(before the introduction of E-Soko)



Markets selected for the period of 2007-2012
(After the introduction of E-Soko)

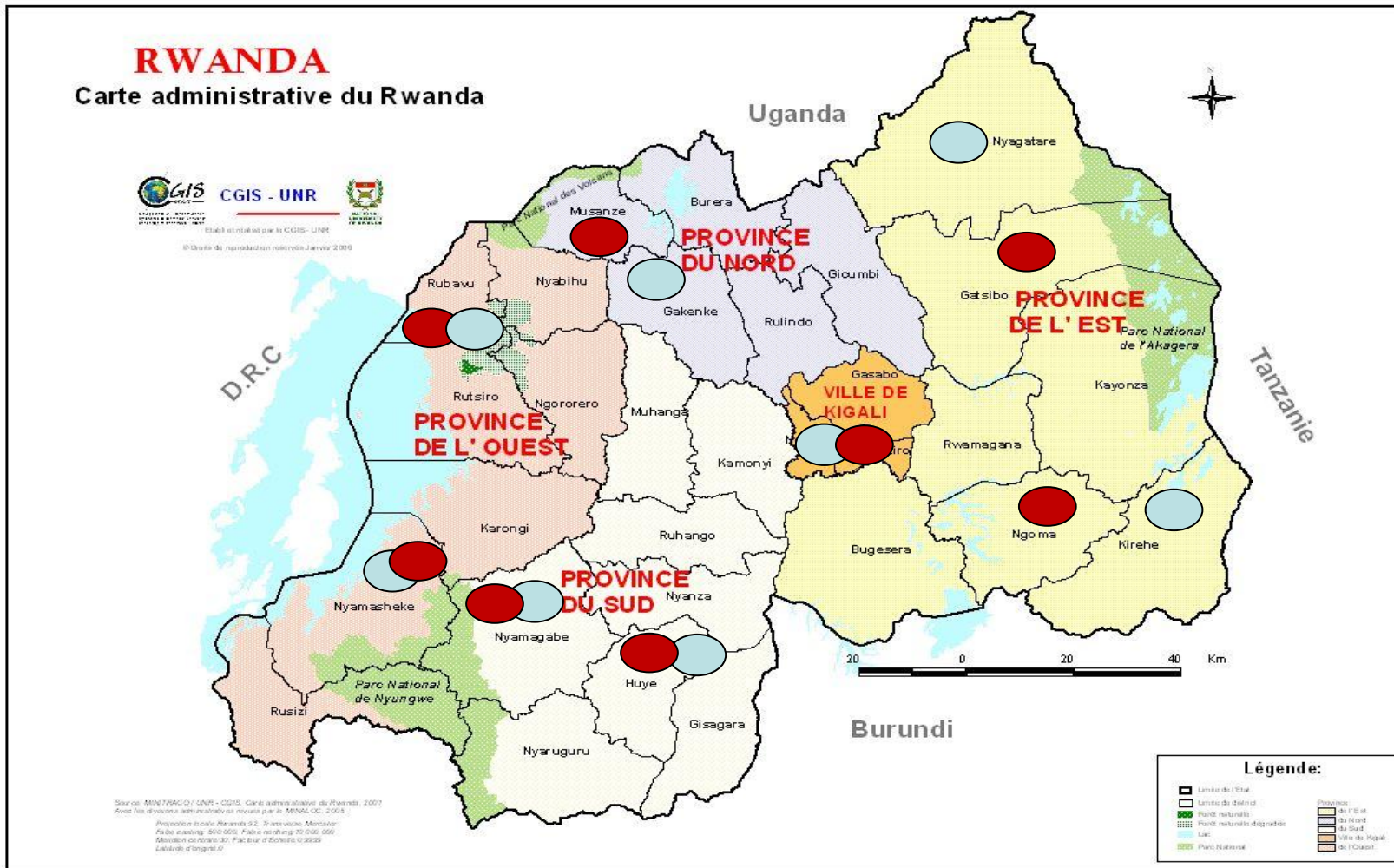


Figure 3. Map of administrative provinces of Rwanda and the beans markets

Theoretical Model and Methods

In the past three decades several research studies have been conducted in the field of market information to determine the degree of interaction between markets using time series techniques (Bessler and Kergna, 2003; Vitale and Bessler, 2006; Chambers, 1984; Chavas and Kim, 2005). The studies sought to evaluate how price is transmitted across markets and determine market integration for a given commodity using vector autoregressive-based methods such as co-integration.

If we assume the existence of co-integration, the data generating process of P_t (price at time t) can be appropriately modeled in an error correction model (ECM) with $k-1$ lags which is derived from a levels vector auto-regression (VAR) with k lags:

$$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \mu + \varepsilon_t \text{ where } t = 1, \dots, T \text{ and } \varepsilon_t \sim \text{Niid } (0, \Sigma) \quad (3)$$

Where Δ is the difference operator ($\Delta P_t = P_t - P_{t-1}$), P_t is (8×1) vector of bi-weekly prices measured at time t from each of ten markets under consideration, $\Pi = \alpha\beta'$, Γ_i is a (8×8) matrix of coefficients relating price changes lagged i period to current changes in prices, Π is (8×8) matrix coefficients relating lagged levels of prices (not changes) to current changes in returns and ε_t is a (8×1) vector of white noise innovations. (Π may be of order 8×9 if we have a constant in the co-integration space)

We will test for co-integration and impose it if the data do not reject co-integration. If co-integration is rejected other VAR model specifications will be investigated. Since it is very hard to interpret the coefficient from VAR estimation, innovation accounting may be the best description of the dynamic structure (Sims, 1980; Swanson and Granger, 1997). The dynamic relationships can be summarized through the moving average

representation. We can then solve for its moving average representation, where the vector P_t is written as a function of the infinite sum of past innovations:

$$P_t = \sum_{i=0}^{\infty} G_i e_{t-i} \quad (4)$$

Where G_i is 8 x 8 matrix of moving average parameters, which map historical innovations at lag i into current position of the vector P_t . Enders (2010) points out that the VMA representation is the main idea of Sims's (1980) methodology that allows to trace out time path of different shocks on variables contained in the VAR model also called impulse response function. In this study we will also employ directed acyclic graph to investigate the contemporaneous causal relationships among innovations of the ten series. Co-integration methods are important in determining the co-movements of variables but do not necessarily inform us on the causality between a set of variables, hence the use of the directed acyclic graphs (DAG) of inductive causation. A directed graph is a diagram that represents a causal flow among a set of variables (Vitale and Bessler, 2006). The important characteristic of inductive causation methods is the conditional independence property on variables to determine different causal flows between variables (Pearl, 1995; Haigh and Bessler, 2004).

Results and Discussion

The evolution of beans prices in both periods (1999-2003 and 2007-2012) show a similar pattern of variation among the price series with a peak for all the prices around October-November (Figures 1 and 2). The prices series seem to have a tendency to return to their long-run mean (mean reversion), wandering up and down in the majority of the cases for both periods. The Augmented Dickey Fuller test was used to test for stationarity of price series (Tables 1 and 2).

Table 1: Test of non-stationary on beans prices for 8 markets in Rwanda, 1999-2003

Market	Levels			First Differences		
	t-test	k	Q (p-value)	t-test	k	Q (p-value)
NYAMASHEKE	-2.555	1	0.894	-5.770	1	0.493
HUYE	-2.791	2	0.465	-13.249	1	0.421
MUSANZE	-1.984	1	0.903	-5.329	1	0.546
NGOMA	-5.024	2	0.730	-5.245	1	0.441
KIGALI CITY	-3.684	1	0.905	-7.302	1	0.801
RUBAVU	-3.084	1	0.484	-6.545	1	0.249
NYAMAGABE	-2.508	1	0.583	-9.404	1	0.323
GATSIBO	-3.142	1	0.611	-5.985	1	0.463

Table 2: Test of non-stationary on beans prices for 8 markets in Rwanda, 2007-2012

Market	Levels			First Differences		
	t-test	k	Q (p-value)	t-test	k	Q (p-value)
HUYE	-3.529	1	0.341	-6.478	1	0.069
NYAMASHEKE	-5.249	4	0.084	-6.217	1	0.038
RUBAVU	-3.709	1	0.270	-5.906	1	0.138
GAKENKE	-2.800	1	0.334	-7.249	1	0.243
NYAGATARE	-3.255	1	0.197	-9.963	1	0.136
NYAMAGABE	-3.027	1	0.080	-7.427	1	0.036
KIREHE	-3.233	1	0.523	-7.380	1	0.253
GASABO	-3.295	1	0.176	-9.391	1	0.112

The null hypothesis on each levels and first difference tests is that the price in each market is non-stationary. The tests results show that, in levels, four prices among the eight price series are stationary while four others are non-stationary (t-statistic is greater than -2.89 at 5% critical value for non-stationary series) for the 1999-2003 time period. For the 2007-2012 period, all the series except one (which is also on the borderline) are stationary. In first difference the calculated t-statistic is less than -2.89 in all cases which reject the null hypothesis of non-stationarity. Q-statistics results show non-autocorrelation for the 1999-2003 time period while some series for the 2007-2012 period have a Q-statistics suggesting the prices to be auto-correlated.

Lag length tests were performed to determine the maximum number of lag for the model in both dataset. Two loss metric tests were carried out: the Schwartz loss (SL) and Hannan and Quinn's measure (HQ). Both metrics showed a minimum number of one lag. We concluded that the model can be appropriately determined by one lag.

Even though the individual series are non-stationary, certain linear combinations of prices in levels from different markets may be stationary, or co-integrated. The trace test determine the appropriate number r of co-integrating vectors (rank test) by a sequential testing procedure as described in Johansen (1992, p.390) and Juselius (2006, p.135). For the 1999-03 dataset, the number of co-integrating vectors is five ($r=5$) while for the 2007-2012 dataset, the number of co-integrating vectors r is equal to 7, which is the maximum number for a vector of eight price series. This means that the price series for the 2007-2012 dataset are perfectly co-integrated. The exclusion and weak exogeneity tests showed that no market was excluded in the co-integrating space and none of them is weakly exogenous. However given the fact that all series (except one which also is on the borderline) for the 2007-12 dataset are stationary and perfectly co-integrated, we considered to model the series as VAR instead of an ECM. Yang, Bessler and Leatham (2000) warn that non-stationarity is needed as a precondition to carry out co-integration analysis (ECM). We did not consider reporting the estimates of the error correction model or VAR coefficients because the individual coefficients are difficult to interpret (Vitale and Bessler, 2006). We are however presenting, in equations (5) and (6), the contemporaneous correlations between price innovations in each market for the 1999-2003 and 2007-2012 periods of study.

Each market name is abbreviated by writing the first and last two letters of the market in the order: Nyamasheke, Huye, Musanze, Ngoma, Kigali City, Rubavu, Nyamagabe, and Gatsibo for the 1999-2003 dataset.

$$\text{Corr. } (e_t) = \begin{matrix} & \text{NYKE} & \text{HUYE} & \text{MUZE} & \text{NGMA} & \text{KITY} & \text{RUVU} & \text{NYBE} & \text{GABO} \\ \left[\begin{array}{cccccccc} 1.000 & & & & & & & & \\ 0.637 & 1.000 & & & & & & & \\ 0.585 & 0.439 & 1.000 & & & & & & \\ 0.627 & 0.609 & 0.559 & 1.000 & & & & & \\ 0.614 & 0.673 & 0.594 & 0.619 & 1.000 & & & & \\ 0.403 & 0.237 & 0.673 & 0.421 & 0.442 & 1.000 & & & \\ 0.662 & 0.720 & 0.528 & 0.632 & 0.654 & 0.372 & 1.000 & & \\ 0.673 & 0.693 & 0.567 & 0.797 & 0.628 & 0.409 & 0.722 & 1.000 & \end{array} \right. & (5) \end{matrix}$$

For the 2007-2012 dataset, the markets are in this order: Huye, Nyamasheke, Rubavu, Gakenke, Nyagatare, Nyamagabe, Kirehe and Gasabo in the capital city.

$$\text{Corr. } (e_t) = \begin{matrix} & \text{HUYE} & \text{NYKE} & \text{RUVU} & \text{GAKE} & \text{NYRE} & \text{NYBE} & \text{KIHE} & \text{GABO} \\ \left[\begin{array}{cccccccc} 1.000 & & & & & & & & \\ 0.039 & 1.000 & & & & & & & \\ 0.276 & 0.077 & 1.000 & & & & & & \\ 0.239 & 0.170 & 0.060 & 1.000 & & & & & \\ 0.309 & 0.167 & 0.243 & 0.316 & 1.000 & & & & \\ 0.058 & 0.382 & 0.063 & 0.225 & 0.330 & 1.000 & & & \\ 0.110 & 0.282 & 0.123 & 0.231 & 0.263 & 0.255 & 1.000 & & \\ 0.152 & 0.144 & 0.058 & 0.211 & 0.312 & 0.151 & 0.233 & 1.000 & \end{array} \right. & (6) \end{matrix}$$

From the correlation matrices we can notice that the correlation between markets for the 1999-2003 dataset is in general present reaching in most cases a correlation value of 0.5 and beyond. But the correlation values for the 2007-2012 dataset are low and none of them reach the value of 0.5. To gain more insight directed acyclic graph (DAG) technique was used to evaluate the contemporaneous correlation between innovations¹. For the 1999-2003 dataset the results show that the beans market in Kigali City, Nyamasheke, Nyamagabe and Ngoma are receiving price

¹ The DAG graph is not presented here to save space. For details on the graph, contact the senior author

signals from Huye, Rubavu and Musanze markets in contemporaneous time. Apparently price signals are coming from deficit regions (Huye) and surplus regions (Musanze and Rubavu) to high demand zone such as the capital city Kigali. For the 2007-12 dataset, the information flow goes from deficit regions of Huye and Nyamagabe to high demand region in capital city and the border regions in the eastern parts of Rwanda (Kirehe and Nyagatare) in contemporaneous time. These results corroborate, in general, the findings by Vitale and Bessler (2006) who reported that the price signal moves from deficit regions to high demand and surplus regions.

Further analysis was carried out to examine the price dynamics between markets during the period before the introduction of the market information system “E-Soko” (1999-2003) and the period after the introduction of E-Soko (2007-2012). The impulse response function² and the forecast error variance decomposition were analyzed respectively to see how the shocks in one series influence other series and how much change in the future (uncertainty) of one market price is caused by another market. Tables 3 and 4 below present the results on the forecast error variance decomposition of beans prices for the two periods at horizon of zero, two, eight and 16 weeks ahead.

For the period of 1999-2003, innovations associated with current prices in the markets of Huye, Musanze, Kigali City and Rubavu are solely explained by own-price shocks. This is not the case for the markets of Nyamasheke, Ngoma, Nyamagabe and Gatsibo where for instance 23.13% of price change in Nyamasheke are explained by Huye, 17.5% of change in Ngoma are explained by Musanze, 34.18% change in price in Kigali City are explained by Huye and 40.64% change in price in Nyamagabe are accounted for by Huye as well in current time. This is pattern showing how price signals are transmitted from deficit regions to high demand regions such as cities. It is not common to see a high price transmission between markets in contemporaneous

² The impulse response function figure is not presented here to save space. Contact the senior author for details

time; price changes in markets tend to originate from local shocks in current time. At longer horizons (8-16 weeks ahead), Musanze market seems to dominate all other markets except Rubavu. In fact Musanze explain about 55% price change in Nyamasheke, about 50% price change in Kigali City, Gatsibo and Nyamagabe at 16 weeks ahead. Musanze, being located in the beans surplus region, sends price signals to deficit and high demand regions such as Nyamasheke, Gatsibo and Kigali City. Musanze can be considered in this case as price leader. Rubavu, another market located in a surplus region, seems to interact in a very limited way with other market, showing some level of isolation. Kigali City, Nyamagabe and Gatsibo are the least exogenous among the markets under study, explained in part by being located in high demand zones (cities) and deficit regions.

For the period of 2007-2012, innovations associated with current prices in the markets of Huye, Nyamagabe and Nyamasheke are solely explained by own-price shocks. However, the markets of Nyagatare, Kirehe and Gasabo show a different trend where for instance about 18% of price change in Nyagatare, are explained by Huye and Nyamagabe combined. At longer horizons, we notice an increase in interaction between markets. For instance at 8 and 16 weeks ahead, 44% price change in Huye, are explained by Nyamasheke, Rubavu and Nyagatare combined. Rubavu, appears to interact more with other markets for this period of study (2007-2012) compared to the 1999-2003 period. Nyagatare seems to account for price changes in several other markets but at the same time it is influenced by other markets under study. At longer horizons, all the markets appear to interact more among each other. Gasabo market in Kigali City is leading other markets with only 32% of price change at 16 weeks ahead explained by own-price shock, followed by Gakenke (36%) and Nyamagabe (42%). No market appears to lead other in terms of price signals. The impulse response function results corroborate above

findings on forecast error variance decomposition. The impulse graphs show for the period of 1999-2003 that Musanze is a dominant market while the period from 2007-2012 is visibly characterized by more interaction among markets led by Nyagatare, Nyamasheke and Huye but there is no distinct market dominant.

In conclusion, for the 1999-2003 period of study, the market of Musanze (located in a surplus region) consistently showed exogeneity characteristics, compared to other markets, by influencing their price changes. Musanze has emerged as a price leader in this group. Huye exhibited similar exogeneity characteristics as Musanze but to a less extent. Kigali City market behaved as a price information receiver (less exogenous) among the eight markets while Rubavu, a surplus region showed little interaction with other markets. For the 2007-2012 study period, findings were mixed showing a high level of interaction between markets but without a clear market leader. One striking observation though about these markets prices is their stationarity behavior which is not consistent with an open market behavior where prices are expected to be non-stationary without any tie to their historical mean. This raises the question of whether the introduction of the liberalization policies since the 1990s and more recently the E-Soko market information platform have helped in opening up the staple food markets in Rwanda. Vitale and Bessler (2006) found non-stationary and co-integrated millet prices in different regions of Mali suggesting the progress and the level of success of the market liberalization policies. Findings from a similar study in Uganda by Rashid (2004) showed that the market integration level among maize markets improved after the introduction of liberalization policies of the mid-1990s. In this case the analysis of the markets for the 1999-2003 time period, a few years after officially introducing the privatization policy (see RDB website), showed better signs of market integration than the 2007-2012 time period.

Table 3. Forecast error variance decomposition on beans prices from eight markets in Rwanda, 1999-2003

Horizon	NYAMASHEKE	HUYE	MUSANZE	NGOMA	KIGALI CITY	RUBAVU	NYAMAGABE	GATSIBO
				(NYAMASHEKE)				
0	53.636	23.137	17.887	1.811	0.268	0.037	0.000	3.224
1	45.793	16.764	31.779	1.079	1.171	0.149	0.041	3.225
4	33.406	8.757	50.218	0.973	3.877	0.370	0.443	1.957
8	28.271	5.968	55.386	1.529	6.330	0.319	0.990	1.207
				(HUYE)				
0	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	94.750	1.627	0.089	0.021	0.114	0.787	2.612
4	0.191	73.709	13.455	1.569	0.062	0.139	2.950	7.926
8	0.641	59.491	22.703	3.959	0.224	0.159	4.253	8.571
				(MUSANZE)				
0	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000
1	0.120	0.881	95.707	0.722	0.425	1.955	0.035	0.156
4	0.956	7.249	75.839	2.608	1.912	11.138	0.043	0.255
8	1.778	12.510	62.243	3.214	2.385	16.779	0.029	1.063
				(NGOMA)				
0	0.000	6.135	17.502	65.363	9.679	1.322	0.000	0.000
1	0.054	12.222	24.619	51.597	10.058	0.826	0.119	0.505
4	0.364	19.750	38.276	29.572	8.083	0.424	0.599	2.932
8	0.570	20.751	46.703	19.996	6.397	0.475	0.998	4.111
				(KIGALI CITY)				
0	0.000	34.189	9.638	0.000	53.945	2.228	0.000	0.000
1	0.950	34.245	14.672	2.184	44.087	1.550	0.192	2.119
4	3.183	25.107	36.427	5.090	24.385	1.042	0.162	4.604
8	4.068	19.113	49.518	5.824	16.155	1.270	0.116	3.935
				(RUBAVU)				
0	0.000	0.000	0.000	0.000	0.000	100.000	0.000	0.000
1	0.003	0.436	0.183	0.000	0.044	99.099	0.215	0.019
4	0.035	1.933	0.625	0.073	0.199	96.475	0.644	0.016
8	0.069	2.783	0.737	0.190	0.343	95.070	0.796	0.012
				(NYAMAGABE)				
0	1.605	40.645	5.481	2.411	3.083	0.208	42.273	4.292
1	3.579	36.700	16.075	2.108	3.690	0.366	32.726	4.755
4	7.336	25.167	38.283	2.252	4.791	0.910	17.487	3.774
8	9.261	19.000	48.005	2.860	5.815	1.559	10.734	2.766
				(GATSIBO)				
0	0.000	24.127	14.890	20.682	3.063	0.418	0.000	36.820
1	0.011	22.928	28.291	16.874	2.477	0.466	0.234	28.719
4	0.017	22.060	43.742	12.740	2.263	0.907	1.422	16.848
8	0.011	23.282	47.237	11.483	2.506	0.873	2.281	12.327

Table 4. Forecast error variance decomposition on beans prices from eight markets in Rwanda, 2007-2012

Horizon	HUYE	NYAMASHEKE	RUBAVU	GAKENKE	NYAGATARE	NYAMAGABE	KIREHE	GASABO	
				(HUYE)					
0	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1	91.395	1.083	5.869	0.023	1.164	0.012	0.236	0.217	
4	65.097	8.267	13.915	0.036	10.872	0.010	0.748	1.055	
8	52.632	13.725	14.208	0.038	16.341	0.010	1.035	2.010	
				(NYAMASHEKE)					
0	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	
1	2.292	90.357	0.491	0.420	6.072	0.014	0.162	0.192	
4	6.527	70.577	3.147	0.870	17.028	0.041	0.141	1.669	
8	8.401	61.896	4.907	0.835	20.641	0.077	0.403	2.840	
				(RUBAVU)					
0	7.636	0.000	92.364	0.000	0.000	0.000	0.000	0.000	
1	9.519	2.787	79.711	0.034	7.902	0.043	0.000	0.004	
4	10.593	11.125	57.571	0.051	19.829	0.031	0.161	0.639	
8	11.109	15.646	48.483	0.058	22.635	0.031	0.442	1.596	
				(GAKENKE)					
0	4.972	0.899	0.004	88.834	0.131	3.154	1.324	0.682	
1	6.841	2.389	1.549	76.539	6.759	3.580	1.901	0.441	
4	8.967	7.937	5.620	49.012	20.983	3.415	3.054	1.010	
8	9.982	12.520	7.161	36.978	25.259	2.767	3.350	1.983	
				(NYAGATARE)					
0	8.623	0.024	2.369	2.376	77.412	9.142	0.035	0.018	
1	7.744	0.970	3.801	2.008	73.293	10.736	1.076	0.371	
4	7.617	5.380	5.237	1.557	65.755	10.271	2.898	1.285	
8	8.397	9.040	6.050	1.366	61.123	8.851	3.246	1.927	
				(NYAMAGABE)					
0	0.000	0.000	0.000	0.000	0.000	100.000	0.000	0.000	
1	0.235	3.084	0.043	0.181	6.518	89.450	0.267	0.222	
4	2.213	12.552	1.547	0.597	22.549	59.026	1.201	0.317	
8	4.594	17.972	3.507	0.655	27.805	42.469	1.763	1.235	
				(KIREHE)					
0	0.258	4.563	0.071	0.071	2.314	3.024	89.698	0.001	
1	3.170	3.657	1.632	0.148	6.905	4.981	79.285	0.221	
4	7.593	4.600	6.045	0.143	16.396	6.153	58.052	1.019	
8	9.037	8.076	7.727	0.132	20.957	5.317	47.034	1.719	
				(GASABO)					
0	1.894	0.930	0.155	0.155	5.063	0.902	2.010	88.889	
1	3.010	1.088	4.350	0.132	13.037	5.043	1.412	71.928	
4	4.301	6.383	8.948	0.093	28.139	8.336	1.125	42.675	
8	5.679	12.452	9.277	0.138	31.935	6.957	1.436	32.126	

Summary and Policy Implications

Bi-weekly prices on beans were analyzed for two time periods: one before the introduction of the market information system “E-Soko” (1999 to 2003) and another one after the introduction of “E-Soko” (2007-2012) on eight markets across Rwanda for each period. Unit root tests (ADF) were used to check for stationarity. They showed that the prices series were all stationary in levels, except one, for the 2007-2012 time period while half of price series were stationary for the 1999-2003 time period. This raised the question on the theory of random walk behavior of prices in an open economy. It is expected in a free market economy where commodity prices are not controlled by the governmental institutions or other market players to vary as new price information comes in and translates in other markets through arbitrage.

Innovations accounting techniques were used to assess the price dynamics between the markets for the two time periods. For the 1999-2003 time period, beans markets seem to be integrated with Musanze market leading the group. Being located in a production surplus region, price signals are coming from Musanze and passed to deficit and high consumption regions such as Nyamagabe, Gatsibo and Kigali City. For the 2007-2012 period, markets prices show a high level of interaction with Nyagatare accounting for price changes in several markets but no apparent price leader emerged from the group.

No definitive conclusions can be drawn from this study regarding the impact of the E-Soko market information system. More studies on beans marketing channels, mechanism of price formation (market power?) and price data collection and reporting processes are needed to elucidate some of the unclear behavior of beans prices especially after the introduction of the E-Soko market information system. Studies on other staple food in Rwanda are as well needed to assess the full impact of E-Soko on the level of market integration in Rwanda.

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