Title: Three decades of market liberalization policy in Mali: An analysis of the grain markets

Jean-Claude BIZIMANA
Assistant Research Scientist
Department of Agricultural Economics
Agricultural & Food Policy Center
Texas A&M University
600 John Kimbrough Blvd / Rm 362 AGLS Bldg
2124 TAMU
College Station, TX 77843-2124
Tel: 979-458-9168 / Fax:979-845-3140
Email: bizimanatex@tamu.edu

David A. BESSLER
Regents Professor,
Department of Agricultural Economics
Texas A&M University
373 B Agricultural and Life Sciences Building
2124 TAMU, College Station, TX 77843-2124
Phone: (979)-845-3096
Email: dabessler@agecon.tamu.edu

Francis KEITA
Deputy Director
Observatoire du Marche Agricole (OMA)
Porte N° 474 - Rue 279, Hippodrome
BP E5589
Bamako, République du Mali
Phone/Fax: (223) 221-40-73
Email: kfrancis.kfrancis@gmail.com

Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, Massachusetts, July 31-August 2

Introduction

Since 1981 the government of Mali adopted the economic reforms comprising price and trade liberalization, reform regarding business regulations and the privatization of state-owned enterprises (Dembele & Staatz, The impact of market reform on Agricultural Transformation in Mali, 1999). Some of the economic reforms were at the heart of the creation of market news services whose aim was to encourage the competitive growth of the private sector by improving market transparency. In that process, the first market information system (MIS) was created in Mali in 1989 as a part of the cereal market reform program and in response to the structural adjustment program reforms by the WB and IMF (Dembele & Staatz, 2004). Furthermore, in 1993 Mali passed a decentralization policy establishing new administrative entities (regions, districts and townships) to decentralize the decision-making process, and drastically reduced the number of civil servants and real government wages. The market liberalization policy was introduced in developing countries by the World Bank and the International Monetary Fund since 1980s through the Structural Adjustment Program (Jayne et al., 1997). Several advocates of market reform posited that the relaxation of controls on private trade and investment would increase productivity and decreases cost. However, the introduction and implementation of the market reforms in Africa have had mixed results and been controversial with some contending that they contributed to the crisis facing smallholder farmers across the continent (Jayne et al., 2002; Coulter and Onumah, 2002).

Before the cereal reforms of the 1980's, the goal of the Malian government was to supply cereal at a cheap price to urban consumers. This led the government to setting up prices regardless of the market conditions established by the supply and demand (Dembele, Staatz, & Weber, 2003). However, in the 1970's, due to drought producer prices were depressed in Mali compared to

neighboring countries such as Burkina Faso. With low prices incentives and slow growth in productivity in the cereal sector, Mali moved from a cereal exporter to a net food importer with annual imports varying between 20,000 to 191,000 tons. This situation pushed the government to initiate in 1981 the cereal market reform program (in French: "Programme de Restructuration du Marché Céréalier" or PRMC). The ultimate goal of the cereal market reform policy was to increase producer income and offer incentives to produce more for the market by facilitating investment based on use of new high crop yield technologies. For this reason, the government removed all the legal barriers to private cereal trade and let the market conditions be determined by the law of supply and demand. With these reforms traders started paying producers prices based on the quality and type of cereal according to consumer preferences. Also the increase in market competition contributed to lower transportation costs from producing farms to consuming urban areas, reducing at the same time the marketing margins by around twenty percent (Dembele & Staatz, 1999). The reforms offered greater marketing flexibility to farmers in terms of choosing the type of crop to grow and sell based on the price differentials; a contrast with the 1970's situation where the prices did not vary by quality and type of crop or time and place. Vitale and Bessler (2006) noted that Mali has been an exception in the West Africa to take on market reforms back in the 1980s. They show the success of the grain market liberalization in integrating markets. This paper is a follow-up of the Vitale and Bessler (2006) articles that analyzed millet price behavior from 1990 to 1997. The goal of the paper will seek to analyze the behavior of grain markets price in Mali (millet, sorghum and maize) in an attempt to re-evaluate the level of the market integration (2000-2012) after adopting the market reforms three decades ago. The paper is organized into three additional sections. First, a brief literature on theory and

market reforms in Africa is offered, followed by a discussion of our method of analysis and empirical results. Lastly, summary conclusions and suggestions for future studies are provided.

The 1980s market reforms in Africa

In general, the ultimate goal of market reforms is to improve an economy's efficiency, by enhancing the productivity of human capital and physical assets (Akiyama et al., 2003). In return, improvements in efficiency are expected to boost economic growth and improve people's livelihoods, especially the poor. Particularly for the commodity markets, economic reforms aimed at letting the market direct the allocation and use of resources and future investment by reducing the involvement of the government in marketing and production, increasing the participation of the private sector and reducing the commodity price distortion. To achieve the reform goals, various measures were taken that included the elimination or privatization of government marketing agencies, the introduction of competition in marketing, the elimination of administered prices, reduction in explicit and implicit taxes, and the privatization of government-owned assets (Akayama et al., 2003 p.1).

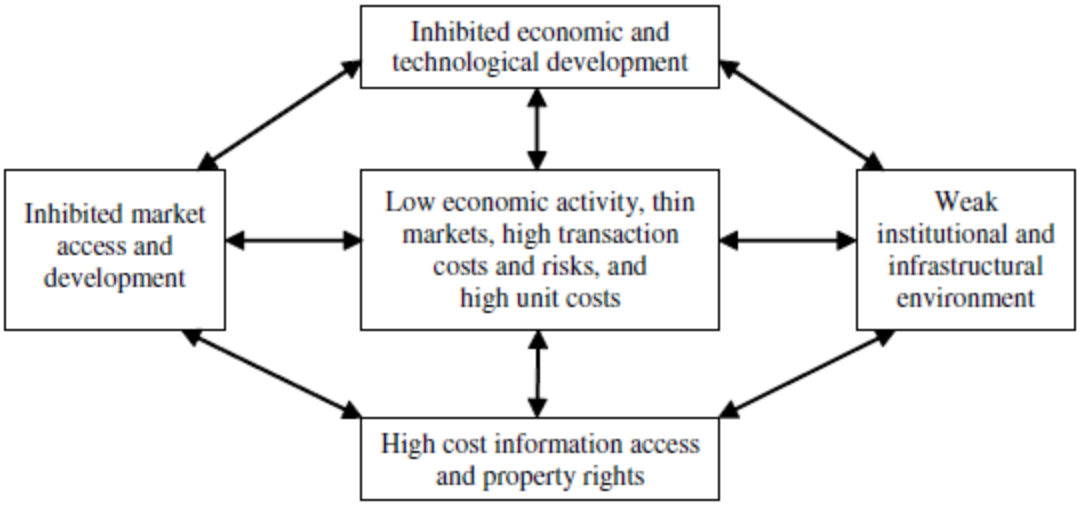
While the success of the economic reforms advocated by the World Bank and IMF remains controversial, some economic events of the early 1980s preceded and influenced the African governments to shift from a centralized to a private-led management of food production and marketing boards. Vitale and Bessler (2006) report that the maintenance and operational costs related to the centralized food programs kept increasing in addition to ill-equipped programs that were unable to manage frequent shocks resulting from both bad and good crop production. Several programs failed and it became difficult for governments to persuade donors for more support to programs that were not sustainable in the long run. Also the commodity market reforms in the past two decades reflected the evolution of development economist's views not

only on the importance of agriculture in economic development but also on the role of government in the development process (Akayama et al., 2003). The change in view was reinforced as well by increasing evidence of inefficiencies of interventionist policies. Increasing pressure to abandon a market control economy became unbearable due not only to some structural changes that happened in the commodity market but also to commodity prices declines during the 1980s and 1990s. The commodity price collapse on the international markets caused several fiscal problems especially for commodity dependent countries (e.g. those from the Sub Saharan Africa) and financial problems to parastatals which managed the commodity sub sectors (Akayama et al., 2003). Several scholars alongside the World Bank and IMF started advocating for market reforms to address some of these issues (see Akayama et al., 2003; Vitale and Bessler, 2006). The push for market reforms by the World Bank materialized mainly through the introduction of the Structural Adjustment Lending (SALs) of the 1980s requiring developing countries to adopt market reforms as a precondition to get loans.

However, the outcome of the adoption and implementation of the market reforms in Africa has been one of the most divisive and controversial topic for scholars and practitioners in the development economics realm (Jayne et al., 2002). Even though some scholars acknowledge that market reforms brought about agricultural growth and food security, others dispute that and attribute the failure of the reforms to inadequate attention to institutional foundation of markets and poor infrastructure. Jayne et al. (2002) argue that the main reason for controversy on the impacts of market reforms is the assumption that countries had already moved into a liberalized market environment before all the necessary preconditions were met (what they call “a false premise”). In other words, there was a naive belief that markets will “instantly” develop right after removing policy constraints without putting in place the institutional arrangement and

infrastructure to support the transition to free market. Dorward et al. (2003) emphasize the role of governments in setting up institutions (or "rules of game") that would govern exchange and reduce the costs and risk of entering and participating in markets. The lack of these institutional arrangements in less developed economies lead to high transaction costs and risks, weak information flows and difficulty to access market resulting in "low level equilibrium trap" and market failure (p.323-324).

Institutions and the low level equilibrium trap



Source: (Dorward, Poole, Morrison, Kydd, & Urey, 2003), p. 324

Yet it would be unfair to just generalize from a few case studies that market reforms and liberalization have failed. The most important reason for this argument is that market institutions evolve gradually than a simple signature on policy change documents (Jayne et al., 2003). There is no doubt that the starting years of reform programs were subject to operate in an environment of weak market institutions. Examples show that several eastern and southern African countries (Ethiopia, Kenya, Zimbabwe and Zambia), failed to implement or reversed the implementation of the market reforms policies. Also price transmission studies have been used as one of the tools

to assess the impact of market reforms policies of the 1980s and 1990s in Sub Saharan Africa (Amikuzo and Ogundari, 2011). They compiled in their study around 45 studies on price transmission published between 1978 and 2011. The findings show a large variability (dispersion) of the coefficient of price transmission (2.5% to 94.2%) and an overall assessment of low level of price transmission in SSA. In order to continue investigating the issue of the impact of the market reforms, this study extends the literature, especially the study by Vitale and Bessler (2006), by presenting empirical results on the level of integration in grain markets in Mali after three decades of implementing market reform policies. It is a follow-up study that will look at the period from 2000 to 2012 and three types of grains (millet, maize and sorghum) on eight cereal market across Mali.

Study area and data collection

The grain market prices analyzed in this study were collected by OMA (Agricultural Market Observatory) from January 2000 to December 2012. The data consist of monthly nominal prices per kilogram of millet, sorghum and maize from eight food commodity markets located in six regions across the country. The markets include Bamako-Niarera, Kayes-Center, Kayes-Nioro, Sikasso-Center, Segou-Center, Segou-San, Tombouctou and Gao. The choice of the markets was solely based on the availability of the price information collected.

OMA was created in 1998 after restructuring and decentralizing the existing market information system (MIS), known by its French acronym as SIM ("Système d'Information sur le Marché") which was created in 1989 as a part of the market reform policies. The goal of the restructure was to make it a demand-driven and sustainable entity. OMA is among the first market information systems (MIS) created in West Africa in line with the Structural Adjustment Plan of the World Bank and IMF (AFD-FOCALES, 2011). They collect price and quantity information

on agricultural, fish, livestock and horticultural products in approximately 66 markets around the country. The markets are selected according to their location near the main cereal commercial hubs. The data collected were sent at a central unit and broadcasted by radio and newsletter.

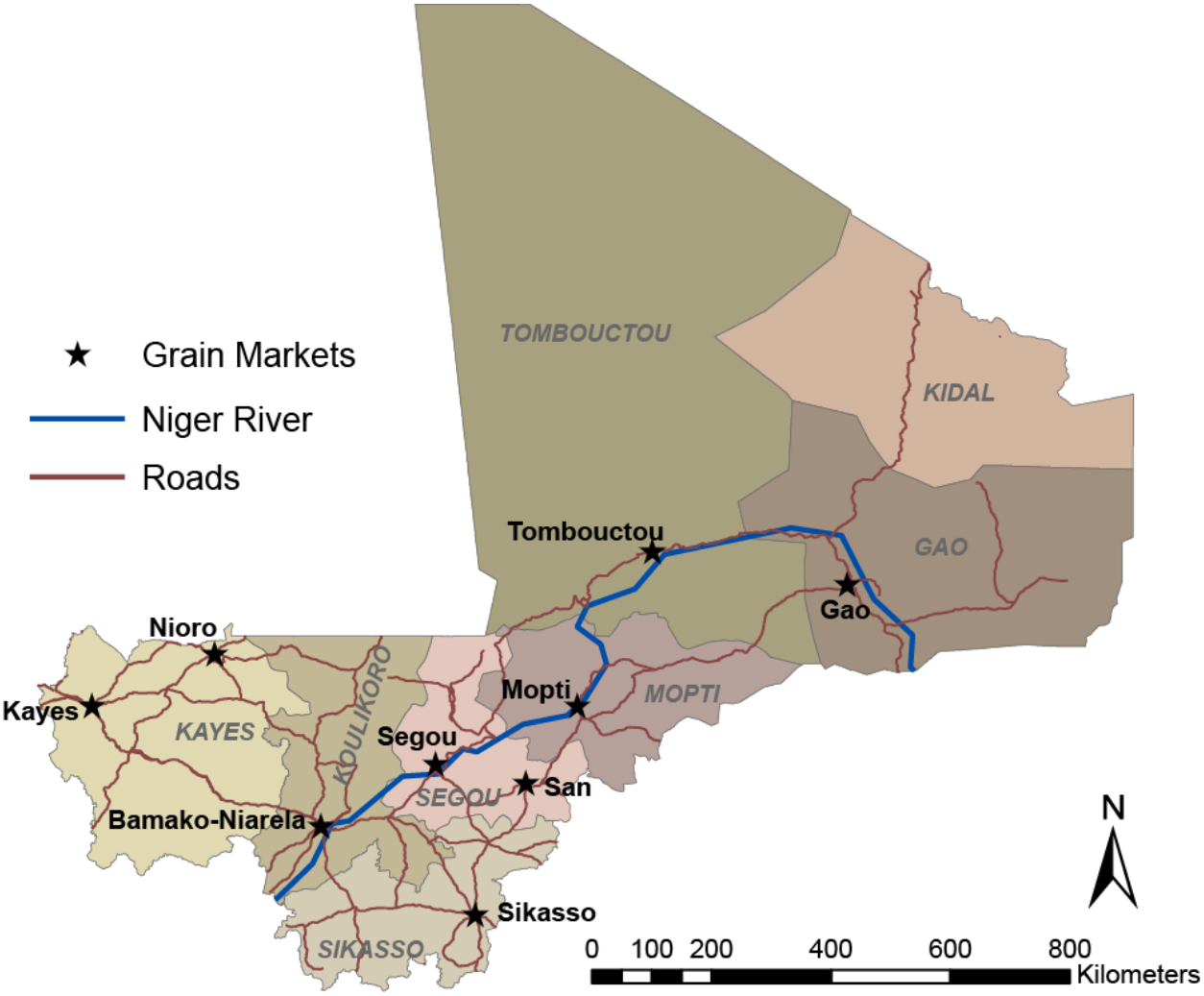


Figure1. Map of eight administrative regions of Mali and the grain markets under study

Methods

One possibility of studying the interaction among variables is through econometric analysis of a set of structural equations or as a reduced form vector auto-regression (VAR). The structural equation form is not generally recommended due to possible endogeneity problems (Enders, 2010). Using matrix algebra, we can transform the structural form into a standard VAR form or reduced form that is more empirically tractable. The VAR was applied here to a vector of prices from *m* markets at period *t* (P_t) of lag order *k*. Its compact form follows:

$$P_t = A_0 + A_1 P_{t-1} + \ldots + A_k P_{t-k} + e_t \quad (1)$$

Here e_t is an m-order innovation vector and A_k, $k=0 \ldots, k$, is an unknown (mxm) coefficient matrix.

To capture more on the dynamic properties of a VAR model, innovation accounting techniques were used. We converted the VAR to its vector moving average representation (VMA) to summarize the dynamic price relationships for the 10 markets in Mali (Swanson and Granger, 1997; Enders, 2010). The forecast error variance decomposition was applied based on the VMA. Forecast error variance decomposition informs us on how much change in the future (uncertainty or error variance) of one market price is explained by uncertainty in other markets.

Traditionally, the Choleski factorization of the innovation matrix was used to provide the causal relationship between series innovations in contemporaneous time. That is, we seek a matrix A such that $e_t = Au_t$, where u_t are independent sources of variation arising in each market, and e_t are the observed innovations in each market, which are not necessarily independent of information arising in other markets. Research has shown that the usual procedure for specifying the ordering of the Choleski factorization required subjective judgment (Swanson and Granger, 1997; Bessler and Akleman, 1998; Demiralp and Hoover, 2003). Here, we used an algorithm

from machine learning (LiNGAM) to provide a structural ordering on residuals from a first stage VAR fit to price data from the 10 livestock markets (Moneta, Entner, Hoyer, and Coad, 2012). The vector P_t is written in its moving average form, as an infinite sum of past orthogonal innovations: $P_t = \sum_{i=0}^{\infty} \theta_i u_{t-1}$ (2)

We used the machine learning algorithm, LiNGAM to find the matrix A such that $e_t = Au_t$

Direct acyclic graphs

The VAR methods are important in determining the interaction of variables but they do not necessarily inform us on the causality between variables. Directed acyclic graphs methods (here the LiNGAM) were used to explain causal relationship among variables. The directed graph approach provides the ability to examine causal flow among a set of variables (Hoover, 2005; Vitale and Bessler, 2006). Capital letters such as $X_1, X_2 \ldots X_n$ are used to represent variables, and lines (edges) with arrowheads at one end represent causal flows (for example $X_1 \rightarrow X_2$ indicates X_1 causes X_2). The graphs with directed edges ($X_1 \rightarrow X_2$) are of importance since they show the direction of the causal flow. Graphs with no cycles are said to be acyclic.

For instance, for three variables A, B and C, if B is a common cause of A and C (A←B→C), then the unconditional association between A and C will be non-zero given the fact that both A and C have a common cause in B (diagram called causal fork). By measuring linear association between A and C, we find that A and C have non-zero correlation. However, if we condition on B, the partial correlation between A and C will be zero. Common causes "screen off" association between their common effects. On the other hand, if we have the variables in the relation, D→E←F, where D and F have a common effect, D and F will have no association or zero correlation if we apply linear association. This diagram is called a causal inverted fork by Pearl (2000). However, if we condition on E, the association between D and F is non-zero or the partial correlation between D and F given E is non-zero. Common effects do not "screen-off" the

association with common causes. Finally, if we have the representation of variables G, H, and I as a causal chain G→H→I the unconditional association (correlation) between G and I variables will be non-zero. But if we condition on H, the association (partial correlation) between G and I, will be zero since H "screens off" association between G and I in a causal chain. Pearl (2000) formalized the screening-off notions into the idea of d-separation that connects formally causal flows and probability representation. Pearl (1995; 2000) under the assumption that the variables follow a Markov process, DAGs can be used to represent conditional independence and determine joint distribution as follows:

$$\Pr(x_1, x_2, \ldots, x_n) = \prod_{i=1}^{n} \Pr(x_i \mid pa_i) \quad (3)$$

Where Pr is the probability of variables $x_1, x_2, \ldots, x_n$ and pa_i (also called Markovian parents) the realization of some subset of the variables that precede (come before in a causal sense) x_i in order $(x_1, x_2, \ldots, x_n)$.

The LiNGAM approach used in this study to determine the causality structure of the millet prices. A causal model is called LiNGAM if it fulfills three properties: 1) the observed variables can be arranged in a causal order, such that no later variable causes any earlier variable; 2) it is a linear causal model; 3) the disturbance terms e_t are continuous valued random variables with non-Gaussian distribution (Shimizu, Hoyer, Hyvarinen, and Kerminen, 2006). A preliminary analysis of the data showed that the residuals from a levels VAR estimation had non-Gaussian error terms.

The estimation of the ECM (including the co-integration analysis), VAR, and innovation accounting were carried out using WinRATS Standard (v. 8.30) and CATS 2 software. The DAG analysis to determine the causal relationship between variables was conducted using TETRAD 5.2.1-3 version.

Results and discussion

The evolution of grain prices (millet, sorghum and maize) over 13 years at nine food markets in Mali shows a predominant pattern of variability among price series with peaks around 2002, 2005 and 2012 for all three grains[1] (Fig. 2, 3 and 4). In general, the three price series seem to follow a random walk pattern. Possible causes of price jump in 2011-2012 are local shock (drought) coupled with the political crisis that broke out following a military coup attempt in March 2012 and the occupation of the Northern part of Mali by rebel groups (WFP, 2012). We notice as well a dramatic increase in price of grains from 2001 to 2004 (peak in 2002) and a slight spike in price for 2005-2006 period. Even though prices can be affected by many factors, it's possible that the price increase in this case was due to increase in demand and a signal of grain market competitiveness (USAID, 2011).

The descriptive statistics in table 1 presents the mean, standard deviation, coefficient of variation and their respective rank in order from the highest (1) to the lowest (9) for 9 millet markets in Mali from January 2000 to June 2013. Kayes market has the highest average price followed by Nioro (same region of Kayes) and Tombouctou. The markets with the lowest averages price of millet are Segou and San (region of Segou). Being located on the border Kayes seems to interact with other cross-border markets which could influence the average price of cereal while Segou's low price could be explained by its location on the main roads axes linking the surplus and deficit regions.

[1] Due to limited space and time, we won't be presenting results and discussion on the other two grains (maize and sorghum) but will be discussed in final paper at a future time.

Millet prices

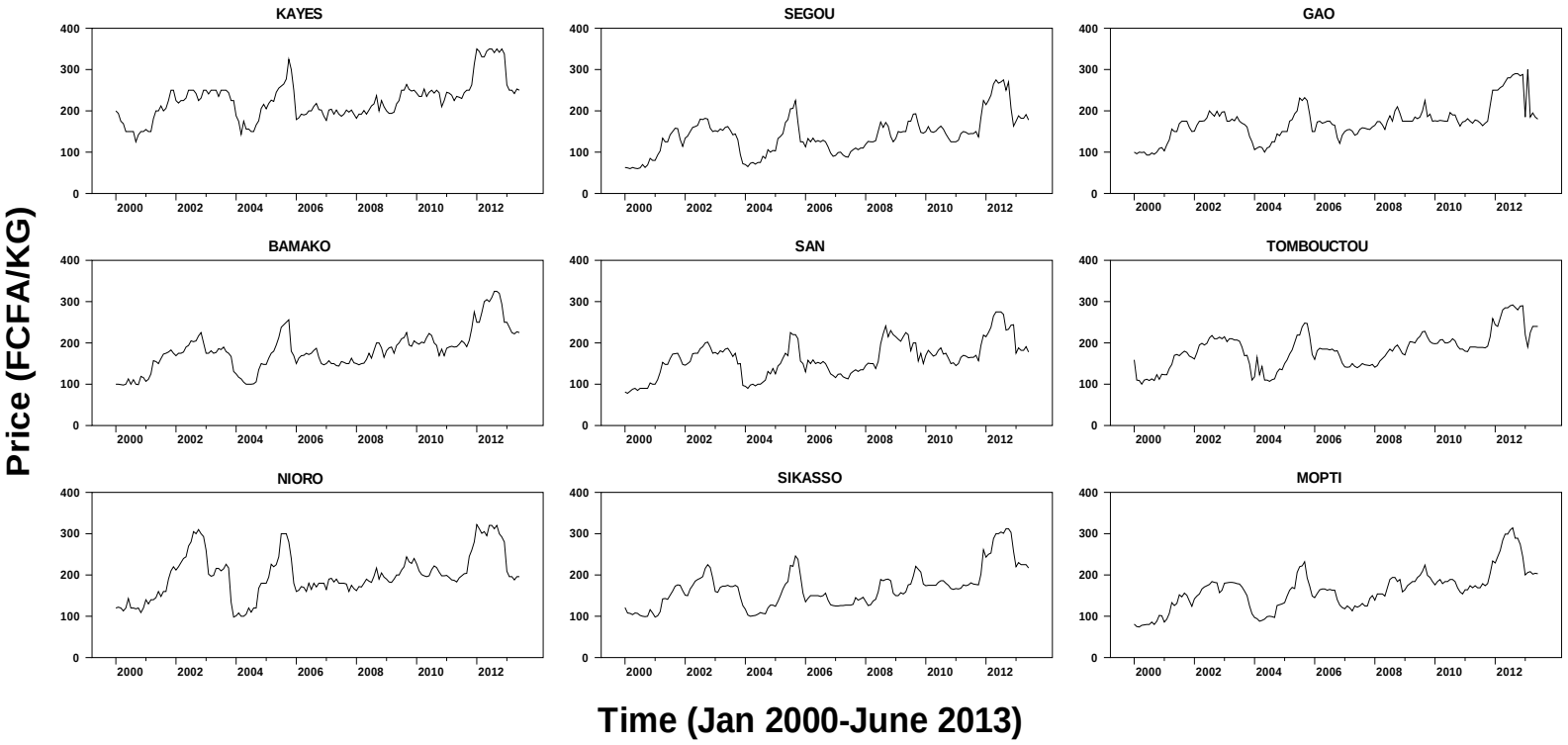


Figure 2. Nominal retail prices of millet in nine food markets of Mali, 2000-2013

Sorghum prices

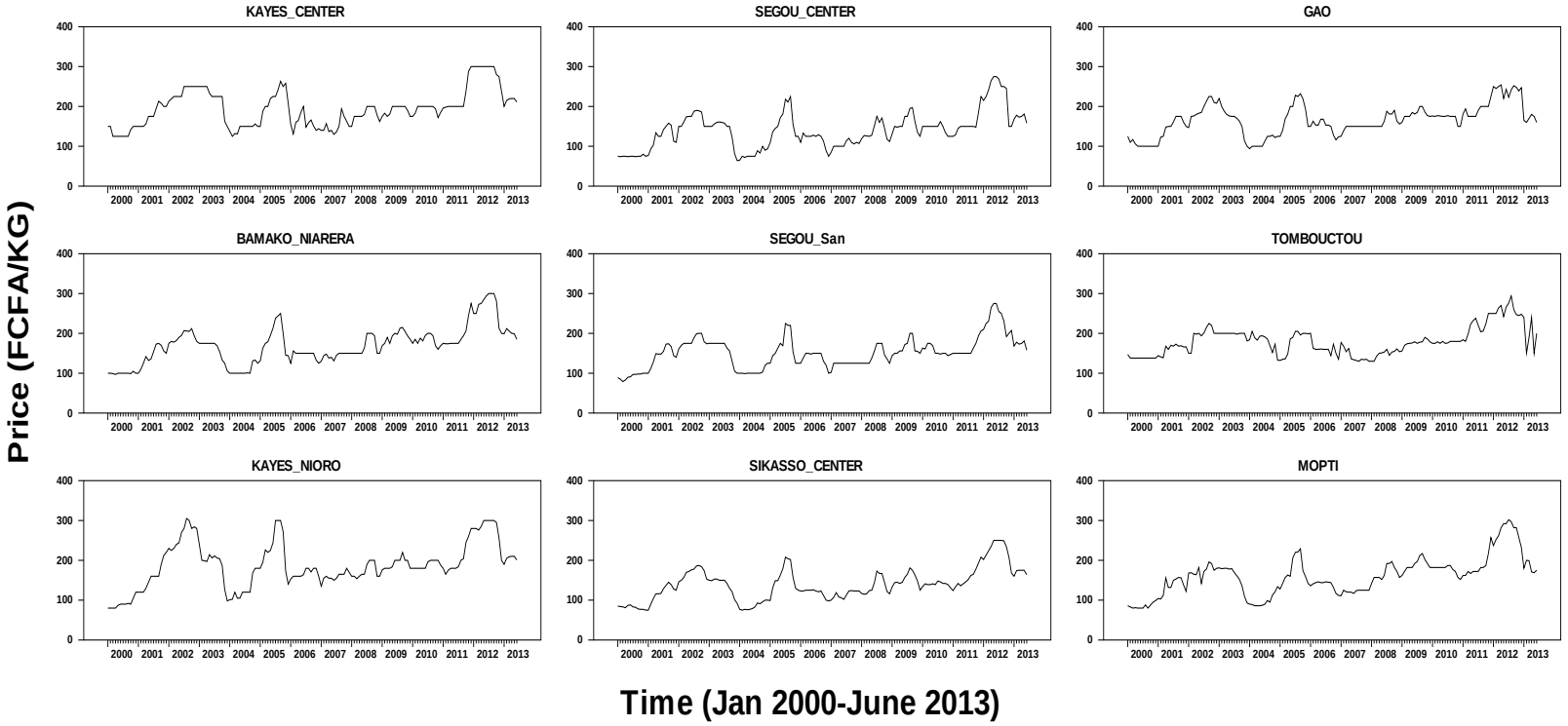


Figure 3. Nominal retail prices of sorghum in nine food markets of Mali, 2000-2013

Maize prices

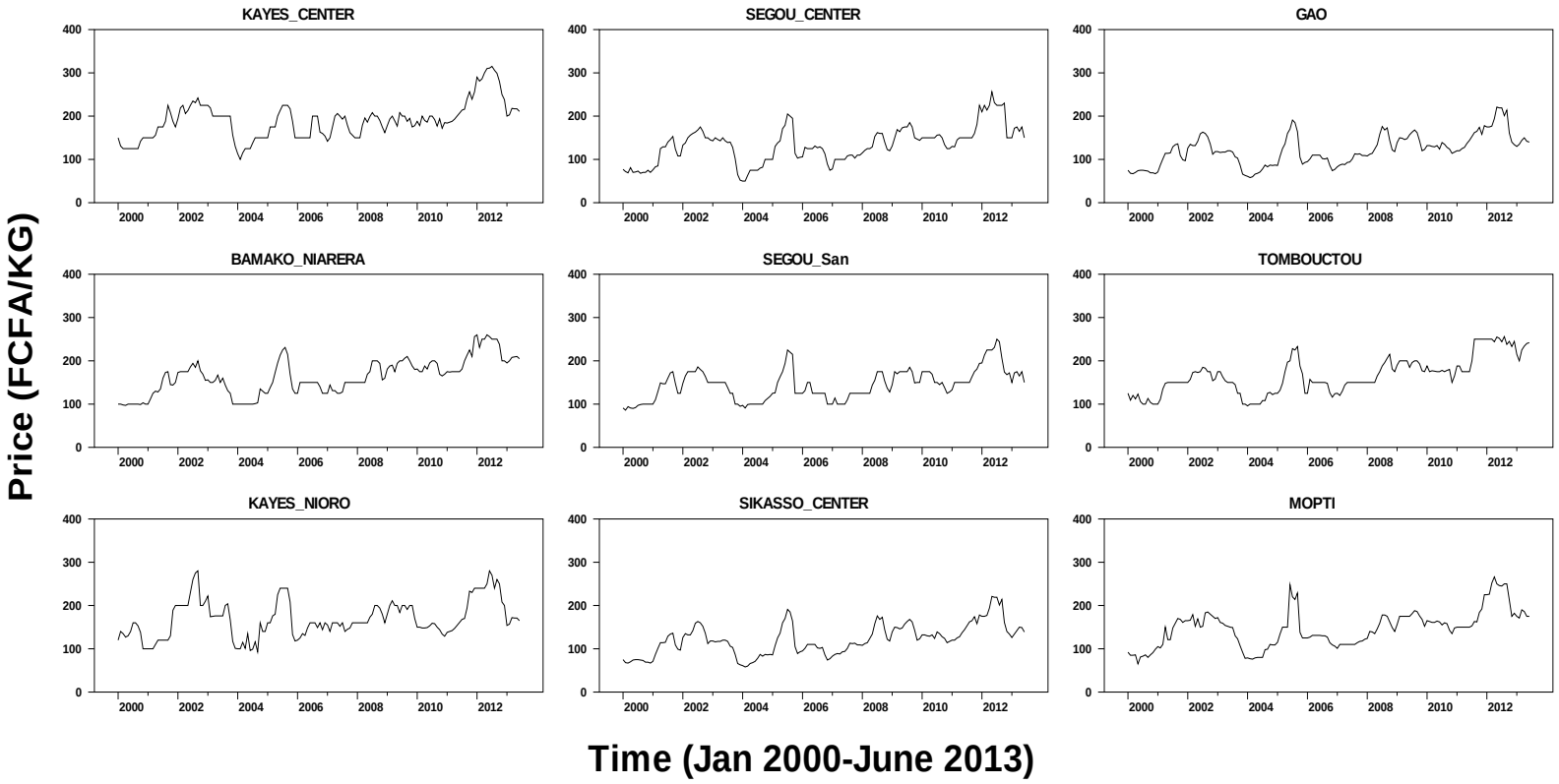


Figure 4. Nominal retail prices of maize in nine food markets of Mali, 2000-2013

Table 1. Summary statistics on millet prices from 9 markets in Mali, 2000-2013

Market	Mean	rank	SD	rank	CV	rank
Kayes	225	1	48.3	5	21.6	9
Bamako	180	4	49.3	3	27.5	4
Nioro	198	2	53.2	1	27.0	5
Ségou	140	9	47.2	6	33.5	1
San	162	8	41.2	9	26.2	6
Sikasso	168	6	48.7	4	29.0	3
Gao	172	5	44.3	7	25.8	7
Tombouctou	183	3	44.2	8	24.2	8
Mopti	163	7	49.6	2	30.4	2

Before we determine if there is any price co-movement among markets, it recommended to examine the price series stationarity. Several tests also called unit root test to determine the stationarity have been around for a long time and include: Dickey-Fuller test, Phillips-Perron and Bayesian to name a few.

The unit root test results on levels from the Augmented Dickey-Fuller (ADF) test revealed that all nine grain market prices (millet, sorghum and maize) were non-stationary. This result supports the findings from Vitale and Bessler (2006) who found non stationary millet prices in ten regions of Mali. However, the trace test to determine whether the grain markets are co-integrated shows a co-integration rank (r) that is equal to nine meaning that all price series are stationary in levels and a VAR in levels is the appropriate model (Vitale and Bessler, 2006).

Table 2. Test of non-stationarity on millet prices from 9 markets in Mali, 2000-2013

	Augmented Dickey-Fuller (levels)			Augmented Dickey-Fuller (1st Diff)		
Market	t-test	k	Q (p-value)	t-test	k	Q (p-value)
Kayes	-2.27	1	32.93 (0.70)	-9.24	2	34.34 (0.63)
Bamako	-1.99	1	45.46 (0.18)	-5.52	2	44.94 (0.20)
Nioro	-2.87	3	82.52 (0.00)	-3.61	1	73.9 (0.000)
Segou	-1.97	1	50.43 (0.08)	-5.81	2	52.08 (0.06)
San	-2.12	1	36.49 (0.53)	-8.49	2	38.49 (0.44)
Sikasso	-2.28	1	52.08 (0.06)	-5.79	2	55.53 (0.03)
Gao	-1.53	1	42.23 (0.29)	-4.16	2	43.24 (0.25)
Tombouctou	-1.95	1	41.05 (0.33)	-5.86	2	36.81 (0.52)
Mopti	-2.14	1	45.17 (0.19)	-5.41	2	45.39 (0.19)

The critical value (t-stat) to reject the null hypothesis (at 5% significance level) of non-stationarity is -2.89. The column named "k" indicates the number of lags of the dependent variable used to produce "white noise" residuals. The value of k results from the minimization of the Schwarz loss metric on values of k ranging from 1 to 3. The column labeled "Q (p-value)" refers to the Ljung-Box statistic (Portmanteau test) test of white noise residuals from ADF regression.

To examine the relationships among the cereal market prices in Mali, several approaches (graphical, statistical and econometric) were used. First, a directed acyclic graph (DAG) was produced from the VAR residuals to explore the contemporaneous correlation among the millet price innovations (Figure 5). The DAG representation helps evaluate the causal flow in current time among the price series from the VAR model estimation. Given that the residuals had non-Gaussian distribution, the LiNGAM algorithm was used to produce the DAG at a prune factor of 0.5. The LiNGAM algorithm consistently estimates the connection strengths and a causal order if the model assumptions hold and the amount of data are sufficient (Shimizu et al., 2006).

Results from the DAG analysis indicated that the Ségou market appears clearly to send price information signals (innovations) to other markets in current time (information source). Kayes market is playing an important role as well in sending price signals to other markets. Conversely, the markets of Bamako and San appear to be price information receivers. The VAR results also confirm the importance of Ségou market in influencing the cereal prices in other markets across Mali. The f-test results from the VAR analysis (Table 3) show that the p-value for the Ségou market is close to zero on all price series indicating not only a strong rejection of the null hypothesis that all coefficients (slopes) are zeros but also the importance of Ségou in influencing millet prices in other markets. There is evidence of a relationship between current millet price variables and their lagged values.

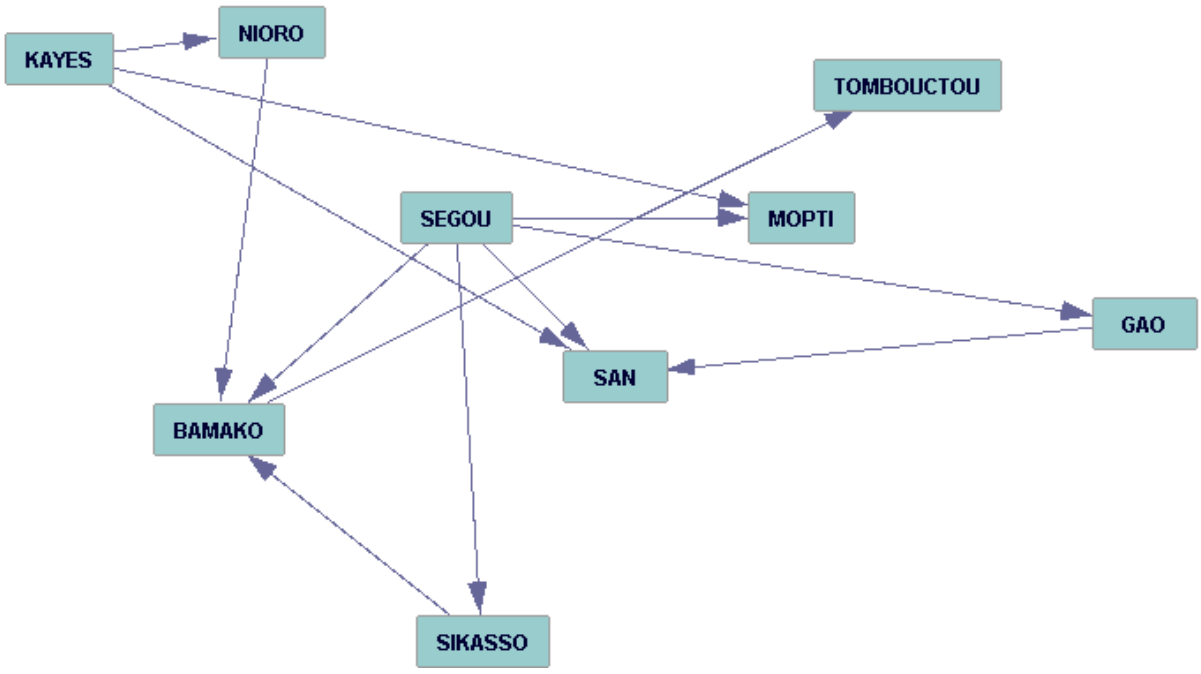


Figure 5. Causal flow found with LiNGAM on innovations from a VAR model on millet prices from 9 grain markets in Mali, 2000-2013

Table 3. F-test on Lagged values of each price series (in each market) on current values of price series

	$PKAY_t$	$PBKO_t$	$PNIOR_t$	$PSEG_t$	$PSAN_t$	$PSIK_t$	$PGAO_t$	$PTOM_t$	$PMOP_t$
$PKAY_{t-1}$	0.000	0.674	0.179	0.846	0.054	0.316	0.241	0.036	0.747
$PBKO_{t-1}$	0.004	0	0.305	0.564	0.577	0.059	0	0.002	0.1
$PNIOR_{t-1}$	0.268	0.02	0	0.055	0.033	0.188	0.011	0.124	0.565
$PSEG_{t-1}$	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
$PSAN_{t-1}$	0.027	0.183	0.089	0.24	0	0	0.118	0.106	0.095
$PSIK_{t-1}$	0.135	0.024	0.072	0	0.027	0	0.021	0.001	0
$PGAO_{t-1}$	0.935	0.426	0.244	0.945	0.357	0.335	0.226	0.642	0.649
$PTOM_{t-1}$	0.597	0.284	0.101	0.942	0.326	0.219	0.045	0	0.574
$PMOP_{t-1}$	0.302	0.001	0.93	0.083	0.005	0.11	0.004	0.158	0

To do an in-depth analysis of the market price dynamics, the forecast error variance decomposition was carried out. The forecast error variance decomposition provides capabilities for analyzing how much change (in percentage) of one market price is influenced by shocks from other markets at different horizons: current time, one and four months ahead (Table 4). For example, uncertainty in current prices in the Bamako market are explained at 55.5% by own-price shocks and at 34.4% by shocks from Segou, while the price uncertainty (innovations) in Kayes is solely (100%) explained by own-price shocks. Surprisingly we notice that innovations associated with current prices and explained by own-price shock are found only in three out of nine markets studied. The remainder of the markets indicate price shocks from Segou market, emphasizing again the role of Segou in influencing millet prices of other cereal markets.

However, as we project further into the future at horizon one and four (one and four months ahead) the interaction between markets continue to increase.

At longer horizons (one and four months ahead), we notice, as expected, higher level of interaction among all markets, with the dominance of Segou market whose impact account on average for 56% change in other millet market prices at horizon four. Only the Nioro market located in Kayes showed less impact of price shocks from Segou market. The influence of Segou appears to emanate from its strategic location on the main road axis linking the South West a surplus production region (that includes Bamako the capital) and the North East which is a deficit region in cereal production. The location plays a role of a commercial hub that facilitates the trade of cereal from South to the North. The Kayes market, being at the border with Senegal, shows limited shocks on its millet prices from other markets under study within Mali supporting the hypothesis of external price shocks from cross-border markets in Senegal.

As for Bamako market in the capital city, the forecast error variance decomposition and the DAG results indicate the market as a price receiver contrary to what would be expected from a consumption region. The Bamako market is heavily influenced by Segou market which account for 34.4%, 51.5% and 61.2% of price changes in Bamako at current time, one and four-month horizon respectively. This level of influence from Segou is as well noticed for the markets of Sikasso (42%, 69%, 76%), San (28%, 46% and 55%) and Mopti (49%, 63%, 62%). Overall Segou market dominates in accounting for price uncertainty in all the rest of the markets under study. The comparison with the findings from Vitale and Bessler (2006) who found Mopti as a dominant and leader market illustrates once again the importance of the central part of Mali (Segou and Mopti) in facilitating the trade of good and reinforce the idea of market competition and freedom.

Table 4. Forecast error variance decomposition on millet prices from 9 markets, Mali 2000-2013

Horizon (month)	Kayes	Bamako	Nioro	Segou	San	Sikasso	Gao	Tombouctou	Mopti
					(Kayes)				
0	100.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.00
1	80.27	2.45	0.41	**15.45**	0.92	0.00	0.08	0.08	0.30
4	39.65	4.15	4.31	**44.88**	2.15	3.93	0.28	0.09	0.50
					(Bamako)				
0	0.14	55.54	1.05	**34.40**	0.00	8.78	0.00	0.00	0.00
1	0.30	37.70	2.13	**51.58**	0.28	4.55	0.47	0.30	2.57
4	2.13	15.88	4.66	**61.23**	0.54	8.58	0.27	0.26	6.41
					(Nioro)				
0	11.66	0.00	88.33	**0.00**	0.00	0.00	0.00	0.00	0.00
1	7.91	0.25	78.83	**10.73**	0.44	0.24	0.89	0.68	0.00
4	5.66	0.15	59.63	**26.12**	0.88	5.57	1.07	0.80	0.09
					(Segou)				
0	0.00	0.00	0.00	**100.00**	0.00	0.00	0.00	0.00	0.00
1	0.20	0.08	0.50	**96.03**	0.21	2.23	0.04	0.00	0.71
4	2.11	0.34	3.69	**77.54**	0.22	13.07	0.05	0.02	2.96
					(San)				
0	0.64	0.00	0.00	**28.35**	62.75	0.00	8.24	0.00	0.00
1	0.33	0.07	0.52	**46.82**	44.25	0.98	4.72	0.26	2.00
4	0.56	0.28	2.75	**55.88**	21.04	10.85	2.18	0.21	6.22
					(Sikasso)				
0	0.00	0.00	0.00	**42.79**	0.00	57.21	0.00	0.00	0.00
1	0.06	0.64	0.25	**69.74**	2.09	25.45	1.05	0.28	0.44
4	1.24	1.06	2.31	**76.52**	3.25	12.47	0.72	0.14	2.30
					(Gao)				
0	0.00	0.00	0.00	**16.06**	0.00	0.00	83.94	0.00	0.00
1	0.00	4.26	1.63	**37.99**	0.47	0.03	51.96	1.27	2.39
4	1.79	3.55	4.93	**50.82**	0.64	6.78	24.07	1.05	6.36
					(Tombouctou)				
0	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	100.00	0.00
1	0.47	2.50	0.63	**27.12**	0.46	0.46	0.00	67.82	0.54
4	0.88	2.77	4.17	**53.83**	0.54	9.70	0.01	23.21	4.90
					(Mopti)				
0	1.48	0.00	0.00	**49.36**	0.00	0.00	0.00	0.00	49.16
1	1.22	0.54	0.08	**63.28**	0.35	2.08	0.00	0.07	32.39
4	2.88	1.17	1.66	**62.01**	0.34	12.69	0.08	0.03	19.15

The impulse response function results (Figure 6) provided the same result in the form of how price in each regional market responds to a one-time-only shock on every other regional price. Each row of the figure gives the dynamic response of a particular regional price to a one-time-only shock in the price, in the region listed at the heading of each column. Segou market shows once again its preponderant role in accounting for price change in other markets.

Conclusions and recommendations

The study sought to analyze millet price interdependence in nine cereal food markets in Mali. The causal flow results indicated the Ségou market as predominantly price information sender while Bamako and San markets behaved as receivers of price information in contemporaneous time. An in-depth analysis using the forecast error variance decomposition showed the same conclusions that confirmed Ségou as accounting for a large price changes in other cereal markets. The Ségou market consistently showed a high level of interaction with other markets across time emerging as a dominant leader among the nine markets. The location of the Ségou market as a hub town seemed to favor this behavior and is an indication of the evolution of cereal markets in Mali toward market liberalization and freedom.

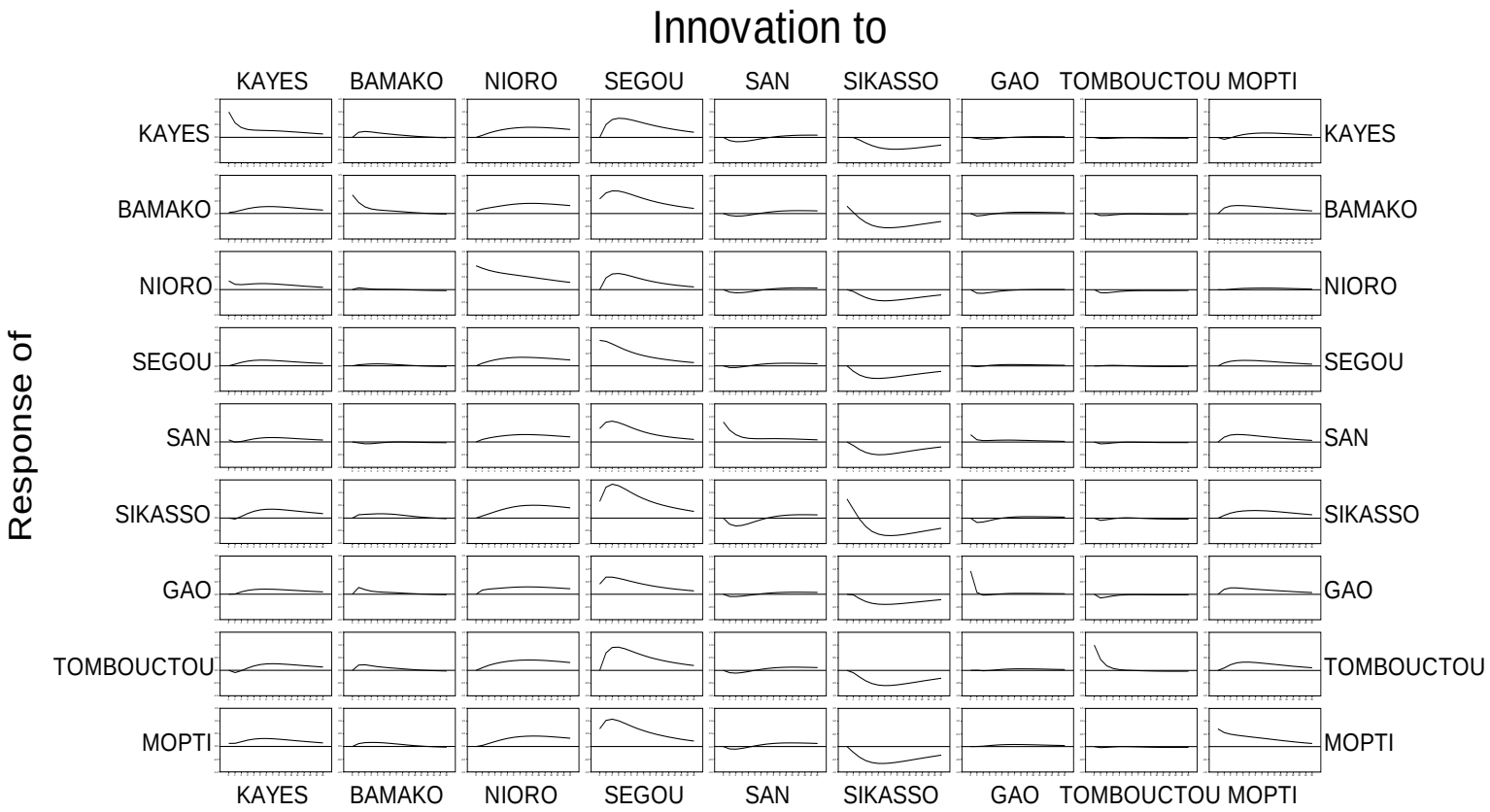


Figure 6. Impulse responses of millet price in each market to a one-time-only innovation in each market, Mali 2000-2013

References

Akayama et al., 2003

Amikuzo and Ogundari, 2011

Barrett, C. B., & Li, J. R. (2002). Distinguishing between equilibrium and integration in spatial price analysis. *American Journal of Agricultural Economics, 84*(2), 292-307.

Bessler, D. A., & Kergna, A. (2002). Price discovery: The case of millet in bamako, mali. *Journal of African Economies, 11*(4), 472-502.

Dembele, N., Teft, R., & Staatz, J. (2000). Mis., 2009.

Dembele, N. N., & Staatz, J. M. (2002). In Jayne T. S., Minde I. J. and ArgwingsKodhek G. (Eds.), *The impact of market reform on agricultural transformation in mali*

Dorward, Poole, Morrison, Kydd, & Urey, 2003

Roche, M. J., & McQuinn, K. (2003). Grain price volatility in a small open economy. *European Review of Agricultural Economics, 30*(1), 77-98.

Jayne et al., 2002;

Moneta, Entner, Hoyer, and Coad, 2012

Coulter and Onumah, 2002

Swanson and Granger, 1997;

Enders, 2010

Vitale and Bessler (2006)

Bessler and Akleman, 1998;

Demiralp and Hoover, 2003

WFP, 2012: Mali: Market Analysis Update, December 2012

http://fscluster.org/sites/default/files/documents/Mali%20-%20market%20analysis%20update%20-%20final%2021%20dec.pdf

(USAID, 2011): MALI AGRICULTURAL SECTOR ASSESSMENT, 2011. MSU-Food Security Team.

http://fsg.afre.msu.edu/promisam_2/MSU_Mali_Ag_Sector_Assessment_2011.pdf