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The Impact of the Market Information Service on Pricing Efficiency and Maize Price Transmission in Uganda

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Abstract

Agricultural market information such as commodity prices, trade volumes and weather conditions, plays an important facilitating role in improving the performance of markets. This research assesses the impact of the agricultural Market Information Service (MIS) on the performance of maize markets in Uganda. Specifically, the research analyzes two performance criteria - pricing efficiency and price transmission for three pairs of markets that trade in maize – three supply markets and one consumer market – over a period of 11 years from 1995 to 2006. The overall conclusion from the research is that the MIS positively influenced market performance in all three market pairs on two broad fronts. First, after the MIS was implemented, a larger portion of the price changes in the consumer market was transmitted to the supply markets, and at a greater speed. Second, with improved access to information, traders responded to opportunities to arbitrage, and as a result generated an additional US$ 1.8 million in 2004.

1.0 Introduction

The International Institute for Tropical Agriculture (IITA) Foodnet project established a decentralized agricultural Marketing Information Service (MIS) in May 1999 with the objective of improving market access and efficiency, and increasing competition in food crop markets. The project collects, tabulates, analyzes and disseminates market intelligence to the farming and trading community on a timely and accurate basis (Okoboi, 2001). The service became operational in September 1999, collecting information on market prices and trade volumes for 32 crop and livestock products from 17 markets scattered across the country. The information was disseminated through the daily newspapers, e-mail and later by mobile phone. Eight years have passed since the establishment of the MIS in Uganda. However, empirical work has not determined whether the service has improved the performance of food crop markets.

The central objective of this research is to assess the impact of the MIS on the performance of maize markets in Uganda. The study analyzes weekly maize price data from the first week of 1995 to the 25th week of 2006 for three supply markets - Masindi, Kasese and Mbale, and one consumer market, Kampala. Specifically, this study examines two questions: (i) what has been the impact of the MIS on the transmission of prices between the three pairs of markets? And (ii) what has been the impact of the MIS on the level of pricing efficiency between the three pairs of markets?

Two data sets are central to this analysis; maize price data and inter-market transfer cost data. Weekly market price data for maize for the time period noted above have been obtained from two sources. The price data for 1995 to the fourth week of 1999 comes from a public online source http://earlywarning.usgs.gov/adds/xceltheme.php, managed by FEWS NET's Africa Data Dissemination Service. The original source of those data was the Ministry of Trade in Uganda. The second portion of the data from week 40, 1999 to week 25, 2006 was obtained from the office of IITA Foodnet in Kampala, Uganda. Transfer cost data are for a point in time, and are extrapolated to form a time-series over the entire data set. Two empirical models are used to address the objectives of the research. The *Houck* model will measure the impact of the MIS on the dynamics of price transmission; more specifically, the magnitude and speed of price transmission before and after the implementation of the MIS. An Ordinary Least Squares

(OLS) linear regression model is developed to measure the unit impact of the MIS on price difference, and therefore efficiency.

Maize supply chain in Uganda

Uganda's maize supply chain consists of two channels. The first channel is of maize grain as a final product, the second channel is of maize flour as a final product, and maize as an input in flour production. This paper focuses on the former. In a typical year, about 15 percent of the total maize production is lost at this stage during post-harvest activities. A further 20 percent of the total production is consumed as subsistence (RATES). An estimated 65 percent of the total maize produced annually is traded. The traders can be described in three categories; rural, urban and large scale. *Rural traders* are located near the producing areas, and link directly with the farmers. They traverse the producing areas on bicycles, motorcycles or small vehicles purchasing maize at the farm gate. The purchased maize is taken to a central point in the urban towns, and then sold to *urban traders*. The main functions of the urban traders are to collect the maize, pre-clean it, bulk it and store it. The urban traders own or rent large trucks and are a major link to final markets. They supply the major wholesale markets of Kampala, major institutions, and to a small extent, they are involved in regional export.

Urban traders are an important link to *large-scale traders* who are mainly engaged in export. Large-scale traders operate under an umbrella company called Uganda Grain Traders Limited (UGT). The major function of UGT is to source export opportunities for Ugandan maize in the region. Domestically traded maize grain is finally sold in urban or rural fresh markets. The leading maize grain markets in Kampala are located in the city centre at Owino, Nakasero and Kisenyi markets. This research will focus on the interactions of urban traders between the three major maize supply markets of Masindi, Mbale and Kasese; and the major consumer market of Kampala.

2.0 Impact of the MIS on Price transmission

2.1 Model development

Transmission of price adjustment measures the flexibility with which price changes are transmitted across markets. In perfectly competitive markets, price increases should be transmitted to the same extent as price decreases. In practice, markets are not perfectly competitive and prices are not always transmitted symmetrically. Symmetry in price transmission is measured two-fold, in magnitude and speed. The magnitude of price transmission measures the size of the increase or decrease that is transmitted from one market to another. For perfectly integrated markets, both an increase and a decrease should be fully transmitted. The speed of transmission refers to the time it takes for the increase or decrease to be transmitted. In the case of wholesale to retail relationships, there is usually a lag in price response due to the time required to collect and transport commodities from one market to another.

A model of asymmetric transmission was initially developed by Rudolf, but the version in equation (1) was specified by Houck (1977). The model involves regression of the cumulative price differentials on the two lagged cumulative price differentials - negative and positive differences.

$$(1) \qquad \sum_{t=0}^{m} \Delta P_{j,t} = a_1 \sum_{t=0}^{m} \Delta P^{1}_{i,t} + a_2 \sum_{t=0}^{m} \Delta P^{11}_{i,t} + \xi$$

$t = 1,2,3 \ldots m$

Where $\sum_{t=0}^{m}\Delta P_{j,t} = \sum_{t=0}^{m} (P_{j,t} - P_{j,t-1})$ is the cumulative first price difference at market *j*; $a_1\sum_{t=0}^{m}\Delta P^{1}_{i,t}$ = summation of the price difference ($P_{i,t} - P_{i,t-1}$) at market *i* if the difference is positive ($P_{i,t} > P_{i,t-1}$) and 0 otherwise; $a_2\sum_{t=0}^{m}\Delta P^{11}_{i,t}$ = summation of the price difference ($P_{i,t} - P_{i,t-1}$) at market *i* if the difference is negative ($P_{i,t} < P_{i,t-1}$) and 0 otherwise. The estimates, a_i, (i = 1, 2) show the cumulative impact of a rise or fall in the independent variable at a given time *t*[1]. The coefficients (a_1 and a_2) measure the *magnitude of price transmission*, for rising (i = 1) and falling (i = 2) prices. The *speed of price transmission* denoted by the average lag (θ), is measured from the following equation derived from Rao and Miller (pp.175).

$$(2) \qquad y_t = \alpha x_t + \delta x_{t-1} + \beta y_{t-1} + \xi_t$$

The average lag implied by equation (2) is computed as:

$$(3) \qquad \theta = \frac{\delta}{\alpha+\delta} + \frac{\beta}{1-\beta}$$

Granger causality tests are usually carried out as a prelude to undertaking price transmission tests. The causality tests are useful for measuring the direction of price causality. And price causality is important to determine which prices in the market relationship cause the other, in other words, in which market do price shocks originate. Results from causality tests are useful in developing the specific models for price transmission tests. The focus of this research will not be on the symmetry in magnitude and speed of price transmission, but rather comparing both the magnitude and speed of price transmission before and after the MIS was implemented.

[1] Appendix 1 provides an example of how the different variables in the model are calculated.

Following Houck (1977), the price transmission equations are specified to capture the separate effects, if any, of price increases and price decreases in one market on price adjustments in another market. For example, how do prices in Masindi respond to price changes in Kampala? Thus, the observations on the dependent variable are the differences between the initial price and the current price in time t, e.g., for Masindi. The right-hand side prices, say for Kampala, are specified as two variables, the cumulative sums of the positive and negative price changes, respectively. A set of three equations is fitted for each market pair: Kampala-Masindi, Kampala-Kasese, and Kampala-Mbale. In each set, separate equations represent the time periods before and after (pre and post) the MIS was implemented.

The Granger causality tests showed that the causality was bi-directional. Following this result, price transmission tests should be carried out for both "directions" of causation (see Appendices 2a-f for detailed Granger Causality test results). That is, changes in Kampala prices causing changes in prices in the supply markets, and vice versa, changes in the prices in the supply markets causing changes in Kampala prices. Due to the endogeneity of the price variables, the results would be similar. Therefore, for this research, price transmission tests are done for one direction – from Kampala to the three individual supply markets. Specifically, measuring what percentage of the price changes in Kampala is transmitted to the supply markets, and at what speed.

The pre and post equations are fitted with the Masindi, Kasese, and Mbale price changes[2] respectively as dependent, and the cumulative positive and negative price changes in Kampala as independent variables. Each equation specification also includes a trend term, which in the Houck specification represents the intercept, and the lagged

[2] Price changes refer to the difference between the price at time *t* and the price at time *t-1*

dependent variable. The full set of variable definitions is given in Table 1. The models specifically answer the following two questions: (i) Has the magnitude of price transmission increased or decreased after the implementation of the MIS? And (ii) Has the speed of price transmission increased or decreased after the implementation of the MIS?

Table 1: Definition of variables

Variable	**Unit**	**Description**
KDPre-up$_t$	UShs/kg	Kampala price difference if difference is > 0; else 0, before MIS
KDPre-up$_t$_1	UShs/kg	Lagged Kampala price difference if difference is > 0; else 0, before MIS
KDPre-down$_t$	UShs/kg	Kampala price difference if difference is < 0; else 0, before MIS
KDPre-down$_t$_1	UShs/kg	Lagged Kampala price difference if difference is < 0; else 0, before MIS
MD[3]Pre$_t$	UShs/kg	Market$_i$ price difference before MIS
MDPre$_t$_1	UShs/kg	Lagged Market$_i$ price difference before MIS
MDPre-up$_t$	UShs/kg	Market$_i$ price difference if difference is > 0; else 0, before MIS
MDPre-up$_t$_1	UShs/kg	Lagged Market$_i$ price difference if difference is > 0; else 0, before MIS
MDPre-down$_t$	UShs/kg	Market$_i$ price difference if difference is < 0; else 0, before MIS
MDPre-down$_t$_1	UShs/kg	Lagged Market$_i$ price difference if difference is < 0; else 0, before MIS
KDPost-up$_t$	UShs/kg	Kampala price difference if difference is > 0; else 0, after MIS
KDPost-up$_t$_1	UShs/kg	Lagged Kampala price difference if difference is > 0; else 0, after MIS
KDPost-down$_t$	UShs/kg	Kampala price difference if difference is < 0; else 0, after MIS
KDPost-down$_t$_1	UShs/kg	Lagged Kampala price difference if difference is < 0; else 0, after MIS
MDPost$_t$	UShs/kg	Market$_i$ price difference after MIS
MDPost$_t$_1	UShs/kg	Lagged Market$_i$ price difference after MIS
MDPost-up$_t$	UShs/kg	Market$_i$ price difference if difference is > 0; else 0, after MIS
MDPost-up$_t$_1	UShs/kg	Lagged Market$_i$ price difference if difference is > 0; else 0, after MIS
MDPost-down$_t$	UShs/kg	Market$_i$ price difference if difference is < 0; else 0, after MIS
MDPost-down$_t$_1	UShs/kg	Lagged Market$_i$ price difference if difference is < 0; else 0, after MIS
$\varepsilon1_t$ and $\varepsilon2_t$		Residual terms

An example set is given in equations (4) and (5) below.

[3] Market$_i$ (MD) refers to the three supply markets Masindi, Mbale and Kasese.

(4) $$\text{MDPre}_t = a_1\sum_{t=0}^{m}\text{KDPre\_up}_t + a_2\sum_{t=0}^{m}\text{KDPre\_down}_t + a_3\sum_{t=0}^{m}\text{KDPre\_up}_t\text{\_1} +$$

$$a_4\sum_{t=0}^{m}\text{KDPre\_down}_t\text{ \_1} + a_5\text{MDPre}_t\text{ \_1} + a_6\text{Trend} + \varepsilon 1_t$$

(5) $$\text{MDPost}_t = b_1\sum_{t=0}^{m}\text{KDPost\_up}_t + b_2\sum_{t=0}^{m}\text{KDPost\_down}_t + b_3\sum_{t=0}^{m}\text{KDPost\_up}_t\text{ \_1} +$$

$$b_4\sum_{t=0}^{m}\text{KDPost}_t\text{\_1} + b_5\text{MDPost}_t\text{\_1} + b_6\text{Trend} + \varepsilon 2_t$$

The estimates, a_i and b_i (i = 1, 2) show the cumulative impact of a rise or fall in the independent variable at a given time t. Those coefficients measure the *magnitude of price transmission*, for rising (i = 1) and falling (i = 2) prices. For equations (4) and (5), the *speed of price transmission* denoted by the average lag (θ) is computed as:

(6) $\theta = \dfrac{\eta_2}{\eta_1 + \eta_2} + \dfrac{\eta_5}{1-\eta_5}$ where $\eta = a$, and b for the pre and post equations respectively.

2.2 Results from Price Transmission tests

Equations (4) and (5) were estimated by OLS, and then tested for any violations of the OLS assumptions using Stata (Version 9) statistical software. For all of the equations, the estimates violated the assumption of homoskedasticity and were corrected using generalized least squares (GLS), and the estimates are reported. All equations had high R-squared values between 0.88 and 0.96 signifying that the models fit the data well. The results are presented under the two categories: pre-MIS, that is before the MIS was implemented and post-MIS, after the MIS was implemented. In total, six equations are estimated, two each for the three market pairs. The results of the price transmission tests are presented in Table 2.

In all of the six market combinations, the magnitude of price transmission in the post-MIS period is greater than the magnitude in the pre-MIS period. Consider the first row of results from Table 2.2 - rising prices in Kampala regressed on changes in Masindi, as an example. Before the MIS was implemented, a unit increase in the price of maize in Kampala led to a 22 percent increase in the price of maize in Masindi. After the MIS was implemented, a unit increase in the maize price in Kampala led to a 54 percent increase in the maize price in Masindi.

Table 2: Results from Asymmetry tests

Dependent variable	Variables/ indicators	GLS Results	
		Pre-MIS	Post-MIS
Masindi	Kampala rising	0.2181** (0.0977)	0.5430* (0.1532)
	Kampala falling	-0.0295 (0.0769)	0.2392** (0.0861)
	R^2 (Adjusted R^2)	0.9101	0.9315
	Kampala rising (average lag)	4.8	2.4
	Kampala falling (average lag)	6.1	4.6
Kasese	Kampala rising	0.0981 (0.0781)	0.3119** (0.1361)
	Kampala falling	-0.1638 (0.1109)	0.1699 (0.1052)
	R^2 (Adjusted R^2)	0.9204	0.8835
	Kampala rising (average lag)	3.1	3.7
	Kampala falling (average lag)	4.9	3.6
Mbale	Kampala rising	0.1874** (0.0816)	0.3612* (0.0904)
	Kampala falling	-0.0006 (0.1086)	0.2741* (0.0790)
	R^2 (Adjusted R^2)	0.9599	0.9300
	Kampala rising (average lag)	7.4	4.8
	Kampala falling (average lag)	9.2	6.0

* Significant at 1%; **Significant at 5%; Standard errors are in parenthesis

This finding implies a larger proportion of changes in maize prices in Kampala was transmitted after the implementation of the MIS, than before. The results are similar in the other two markets. The price share for rising prices received by the traders in Kasese and Mbale increased from 10 percent to 24 percent and from 19 percent to 36 percent respectively. In all three cases, the traders in the three supply markets (Masindi, Kasese and Mbale) were the beneficiaries of this increase. Conversely, a larger portion of falling prices in Kampala was transmitted to traders in the supply markets. This implies that when prices fall in Kampala, a larger magnitude of that fall was transmitted to the supply markets after the MIS was implemented.

It is important to note that the percentage change (increase or decrease) is not entirely to the supply traders' benefit (or loss). The prices are also transmitted further down the supply chain to other players like small rural traders and eventually farmers. This means that, although traders in the supply markets receive a larger portion of price changes, those changes may also be transmitted to other beneficiaries. However, due to the unavailability of data, the magnitude of price transmission further down the chain is not calculated.

In five out of the six market combinations, the speed of price transmission increased in the post-MIS period. This implies that since the implementation of the MIS, price changes are transmitted from Kampala to the supply markets faster. The results in both dynamics (magnitude and speed of transmission) are positive for maize traders. Not only do they receive higher prices after the implementation of the MIS, these prices are received within a shorter amount of time. However, the caveat to this finding is that trade must take place.

3.0 Implications of the MIS on pricing efficiency

Efficiency is a measure of performance, and can be described in three categories. *Technical efficiency* refers to the effectiveness with which a given set of inputs are used to produce outputs. *Operational efficiency* refers to a reduction in costs without necessarily affecting the output side. The third category, which will be the focus of this research, is *pricing efficiency* or *allocative efficiency*. Market systems that are price efficient are able to allocate resources in accordance with consumer preferences. In other words, prices fully represent consumer preferences, and the market system directs resources from lower to higher-valued uses. The goal of pricing efficiency is efficient resource allocation (Kohls and Uhl, 37). Under a free market economy, private players are expected to arbitrage by transferring commodities from lower-priced regions to higher-priced regions and in so doing, exploit profit opportunities and maintain equilibrium. A large portion of the literature often refers to pricing efficiency as market efficiency.

Under the neoclassical paradigm, *competitive market equilibrium is the condition for spatial market efficiency*. Barrett and Li (2002) define competitive market equilibrium as the condition in which "extraordinary profits are exhausted by competitive pressures, regardless of whether this refers to the physical trade flows between markets." The concept implies there are no opportunities for profitable arbitrage if markets are in equilibrium. This is consistent with the First Theorem of Welfare Economics that guarantees that a competitive market will exhaust all of the gains from trade (Varian, pp 555). This implies that an equilibrium allocation will be Pareto efficient.

Considering two spatially distinct markets that trade in a homogenous commodity (i.e. are integrated), the price differential between these markets must be equal to the cost of transferring that commodity from one market to the other. If the price differential exceeds the transfer costs, we can expect trade to occur from the lower priced market to the higher priced market until equilibrium is restored. For competitive spatial equilibrium, two spatial arbitrage conditions must hold:

(6) $P_{jt} = P_{it} + T_{jit}$ when trade occurs

(7) $P_{jt} < P_{it} + T_{jit}$ when trade does not occur

Where P_{it}, P_{jt} refer to the price of a homogenous commodity at markets *i* and *j* respectively at time *t*; and T_{jit} refers to the transfer costs from market *i* to market *j* at time *t*. Equation (6) is referred to as the Law of One Price (LOP), and is the theoretical model around which most empirical models measuring efficiency are designed.

3.1 Model Development

The least squares model, specified in equation (8), is derived from the equilibrium condition for efficiency (see equation (6)). According to the LOP, markets are in equilibrium (or efficient) when the price difference between those two markets equals the cost of transferring a commodity from one market to another. Equation (8) uses regional price differences (PD) as the dependent variable, that is, the difference between Kampala and the individual supply markets. The intuition behind using PD as a dependent variable is that any factor that can trigger increased exploitation of arbitrage opportunities between a pair of markets should have a negative effect on the price difference. One such factor is information. It is expected that when price information is provided to the traders in the maize chain, they will trade appropriately (that is, transfer from a low-priced (P_i) market to a high-priced market (P_j)) and realize profit. As a result of exploiting this trade opportunity, one of five things will happen. One, the price in the low-priced market will increase ($\uparrow P_i$, P_j remains constant); two, the price in the high-priced market will decrease ($\downarrow P_j$, P_i remains constant); three, both prices will change ($\downarrow P_j$, $\uparrow P_i$); four, the price in the low-priced market increases by a greater proportion than the price in the high-priced market ($\uparrow P_i > \uparrow P_j$); and five, the price in the high-priced market decreases by a greater proportion than the price in the low-priced market ($\downarrow P_i < \downarrow P_j$). In any of the five cases, the regional price difference will reduce.

$$\text{(8)} \quad PD_t = \alpha_0 + \alpha_1 \sum_{t=0}^{j} PD_{t-j} + \alpha_2 TC_t + \alpha_3 Seasonality_t + \alpha_4 MIS_t + \alpha_5 \sum_{t=0}^{k} Rainfall + \alpha_6 Trend_t + \varepsilon_t$$

Where *j* is the number of lags for regional price difference, and *k* is the number of rainfall lags.

The independent variables in the model are expected to have an impact on the regional price difference by either influencing the price in the supply market or the price in the demand market. The variables include: lagged regional price differences, inter market transfer costs (TC), a dummy variable for seasonality, a rainfall variable, a trend term, and a variable for MIS. In order to determine how many lags of the dependent variable should be used in the final model, the regional price difference is first regressed on five lags. The estimate of unit transfer costs consists of two variable components: unit transport costs and non-transport costs. Non-transport costs consist of unit trader margins, labour costs and contingency costs. Trader margin represents the wage of the trader; labour costs cover activities such as loading and offloading the maize onto the transportation vehicles; and contingency costs include security, grain losses incurred during loading/off-loading, storage, vehicle repair and maintenance. The two components are extrapolated using time-series variables over the period of analysis[4]. TC is expected to have a positive impact on the regional price difference. As the cost of transferring maize from the supply regions to Kampala increases, according to the law of one price, the regional price difference is expected to increase.

The seasonality dummy is expected to capture the seasonal effect of agricultural production and harvest on the regional price difference. The variable is one (1) for the months of June to August, December and January, and zero (0) otherwise. During those

[4] The survey was undertaken between January and March 2002. The survey reports that the price of maize in Masindi at the time was UShs 110/kg. This price corresponds with week 10 in the time series Masindi price data. As a result, the time series transfer costs were extrapolated from week 10 in 2002. The estimate is extrapolated using two data sets. Transport costs are extrapolated using fuel prices (pump price); while non-transport costs are extrapolated using time series transport consumer price index. Refer to Appendix 3 for an explanation of how the transfer costs were calculated.

months, it is expected that increased trading activity should lower the price difference until it is equal to inter market transfer costs. A limitation to this variable is that it assumes that the specified months will have a consistent impact on the price difference. In other words, if the harvest is expected during the months of June to August, the seasonality effect will not be captured in years when the harvest is irregular. This may be the case when either the rains are delayed, or if they start earlier than expected.

To address this anomaly, seasonality was modeled using monthly rainfall data obtained from the annual Statistical Abstracts. There are two likely impacts of rainfall on the regional price difference. First, heavy rainfall may damage transport infrastructure and increase the cost of transferring maize from the supply regions to Kampala, and subsequently increase the price difference. In addition, heavy rainfall may also damage the crop in the field and/or in storage and result in shortages in the market, and therefore high prices. Second, "good" rains (at whatever time of the year) will lead to a good harvest, which would lead to lower food prices. It is important to note that the duration from planting to harvesting maize ranges from 3 to 4 months. Given the various likely impacts of rainfall on prices and price differences, 6 lags are included – from week 1 to week 3, and from week 12 to week 14.

The MIS variable, measures the impact of MIS on the regional price difference. The variable has a value of 0 prior to week 40, 1999, and then increases linearly to 1 by Week 40, 2000, and has a value of 1 thereafter. In modeling this variable, two assumptions are made. The first assumption is that the MIS policy took one year (from week 40 in 1999 to week 40 in 2000) to reach its full impact on the market actors. The second assumption is that the policy has a linear impact, as opposed to an impact with an alternative functional form. This means that the adoption or utilization curve for the adopters of the MIS was linear. Appendix 4 is a graphical representation of the MIS variable. The final model shown in equation (8) utilizes the entire price data set from week 1 in 1995 to week 25 in 2006, including the 35 forecasted observations as proxy values for the missing data.

3.2 GLS Results

Table 3 shows the results from the OLS regressions of the regional price difference on the various independent variables. The assumption of homoscedasticity was tested using the Breusch Pagan/ Cook Weisburg test, and was rejected in all three models.

Table 3: GLS Regression results for impact of MIS on efficiency

Variables	Dependent variable (Regional price difference, PD)					
	Kampala - Masindi		Kampala – Mbale		Kampala - Kasese	
	Coefficient	Std errors	Coefficient	Std errors	Coefficient	Std errors
PD lag (1st wk)	0.6931*	0.0588	0.7002*	0.0589	0.7007*	0.0793
PD lag (2nd wk)	-0.0540	0.0722	-0.0539	0.0732	0.0854	0.0726
Seasonality	6.8746*	2.930	4.9175*	2.4273	4.1895**	2.4829
Trend	0.0518	0.0363	0.0342	0.0346	0.0450	0.0309
Transfer Cost	-0.5180	0.7066	-0.2791	0.7076	-0.0398	0.5270
MIS	-8.906	5.9921	-7.1329	6.0001	-13.3386**	6.3246
Constant	11.6202	16.3113	13.3108	16.7612	5.8486	15.3501
R^2	0.6422		0.6364		0.6330	

* Significant at 5% ** Significant at 10%; - Variables not included in regression

The models were subsequently run using generalized least squares (GLS), and the results are reported in Table 3. The models are a fairly good fit, with R^2 ranging between 63 and 64 percent. Most of the results in Table 3.1 are expected. The important research variable, MIS is negative in all cases, but only statistically significant in the case of Kasese (however, the absolute t-ratio is greater than one (1) in the Masindi and Mbale cases). The negative sign implies that the MIS policy intervention resulted in a reduced price difference in all three markets. The low t-ratios imply that the impact was not statistically significant in Mbale and Masindi. The size of the coefficients is also important. The MIS policy resulted in a reduction of between UShs/kg 7 and 13 in the three market pairs. Neither transfer cost nor trend is statistically significant in any of the markets. On the other hand, seasonality was found to be significant and positive in all the market pairs.

3.3 Economic impact of the MIS on the Maize Industry

The impact of the MIS on the economy is an estimate of how much revenue has been generated as a result of increased trade. Recall that the unit impact of the MIS, obtained from the least squares regression results in Table 3, signifies that more maize was traded, and as a result the price difference reduced. Figure 1 is a graphical explanation of how prices and quantity traded changed after the MIS was implemented. Using the figure, a detailed explanation of the derivation of the exact economic benefit ensues.

Consider two markets; market (M) that supplies maize to a consumer market - Kampala (K). Ss and Dd are the supply and demand curves for M, while ESs_1, ESs_2 and EDd are the excess supply and excess demand curves for Kampala. For ease of explanation and to keep the graphs simple, two assumptions are made: (i) there are no transaction costs to trade between market (M) and Kampala, and (ii) Market (M) is a small exporter of maize to Kampala, implying that exports from M are not sufficient enough to impact the maize price in Kampala – hence the perfectly elastic excess demand curve in Kampala[5]. The second assumption implies that the entire price change will be felt in the supply market (M), that is, the supply market traders realize the entire benefit of the MIS. In practice, the revenue benefit is shared between all the traders in the supply chain.

[5] If market (M) was larger, then the excess demand curve would be less elastic, and the exports would influence the prices in both markets.

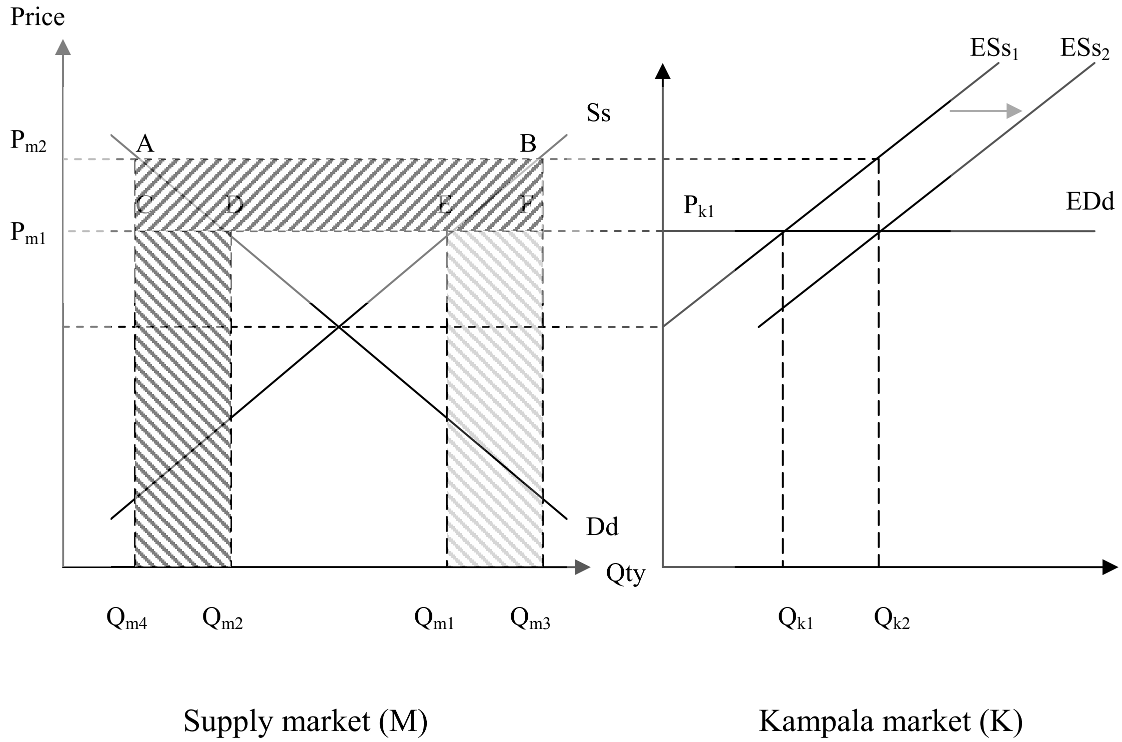

Figure 1: Graphical explanation of Economic impact of MIS

Before the MIS was implemented, market (M) supplied quantity Q_{m1}, but demanded Q_{m2}, and therefore exported (Q_{m1}-Q_{m2}) to Kampala at price P_{m1} (which equals P_{k1} in the absence of transfer costs). Total revenue generated from trade during this period was represented by the area $DEQ_{m1}Q_{m2}$. After the MIS was implemented, market M increased her quantity supplied from Q_{m1} to Q_{m3}. This raised the price in market (M) from P_{m1} to P_{m2}, and therefore the quantity demanded in market (M) reduced from Q_{m2} to Q_{m4}. Exports to Kampala increased from (Q_{m1}-Q_{m2}) to (Q_{m3}-Q_{m4}). Increased exports led to a right-ward shift of the excess supply curve from ESs_1 to ESs_2. But since market (M) is a small exporter, Kampala price remains constant at P_{k1}. New trade revenue (not the change in trade revenue) for market (M) is represented by the area $ABQ_{m3}Q_{m4}$. The additional revenue as a result of the MIS would be the shaded area, that is, the difference between the two areas $ABQ_{m3}Q_{m4}$ - $DEQ_{m1}Q_{m2}$. Or, the sum of the areas of the three shaded rectangles – ($ABCF + CDQ_{m2}Q_{m4} + EFQ_{m1}Q_{m3}$).

For ease of calculation, the revenue generated as a result of the MIS is the sum of two area components, as shown in equations (9) and (10):

(9) ABCF = [increase in price ($P_{m2} - P_{m1}$)[6]] * [total exports after MIS (Q_{m3}-Q_{m4})]

(10) $CDQ_{m2}Q_{m4} + EFQ_{m1}Q_{m3}$ = Δ in exports [(Q_{m3}-Q_{m4})-(Q_{m1}-Q_{m2})] * old price (P_{m1})

The data to calculate these areas are not all readily available, and therefore some assumptions are made. In equation (9), the increase in price is equal to the coefficients of MIS (as shown in table 3); total exports are calculated in the next subsection. Equation (10) has two variables – Δ in exports and old price. Due to the paucity of trade data, I assume that Δ in exports be 5%. That is, the exports increased by 5% after the MIS was implemented; and old price is calculated from the research data collected by the IITA Foodnet project.

Calculation of export trade volume (Q_{m3}-Q_{m4})

There is no secondary information on the specific volumes of maize trade from the three supply markets to Kampala, and therefore estimates are made. Figure 2 shows how the estimates for trade volume are derived.

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[6] ($P_{m2} - P_{m1}$) = the coefficient of MIS which is the change in regional price difference (assuming that the change is entirely due to an increase in the supply market price)

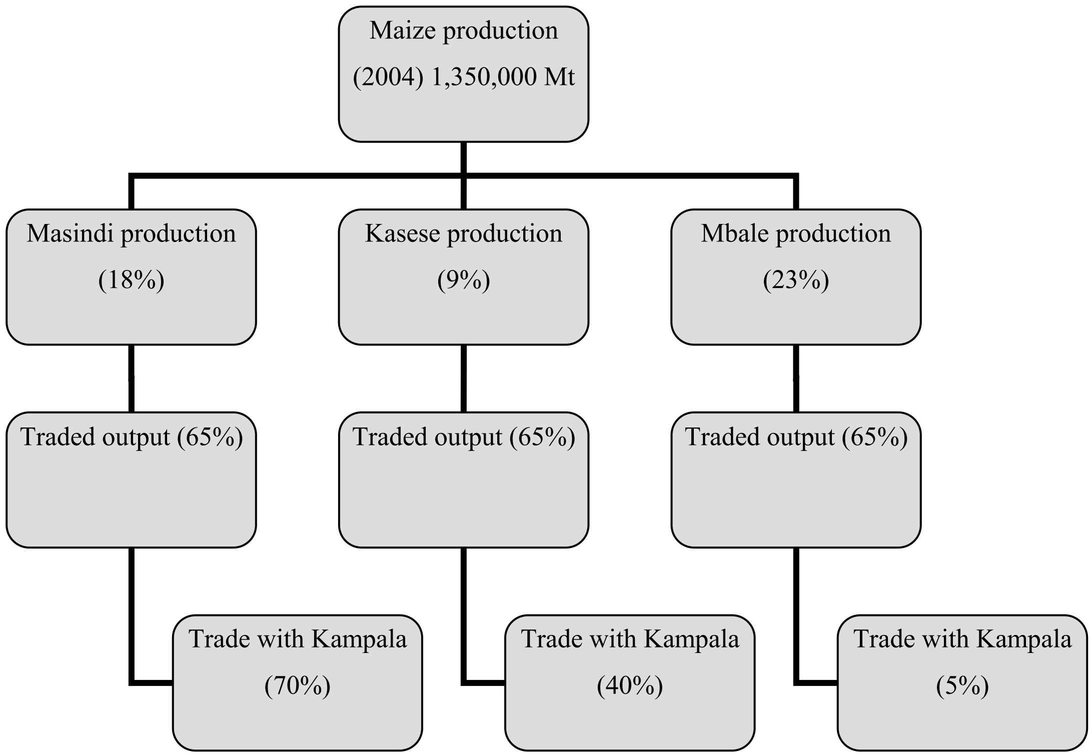

Figure 2: Deriving the volume of maize trade between the supply markets and Kampala in 2004

Total maize production in 2004 was 1.3 million metric tonnes. According to the RATES survey report, the three supply areas – Masindi, Kasese and Mbale contribute 18 percent, 9 percent and 23 percent to annual production respectively. The report also estimates that 65 percent of what is produced nationally is traded. Several assumptions are made at this point. The first assumption is that 65 percent of what is produced by each of the three supply markets is traded. The next set of assumptions is the percentage of total traded output (for all three supply markets) that is destined to Kampala. Those percentage estimates are centered on the statistic that 50 percent of all traded maize is destined for Kampala. Using this indicator, the assumption is made that 70 percent of Masindi maize trade is with Kampala. The estimate is above the national average of 50 percent because of all the major producing regions, Masindi is the only region that does not export maize.

Since maize from Kasese is exported to Rwanda, the assumption is that 40 percent of maize from Kasese is traded with Kampala – slightly below the national average of 50 percent. In the case of Mbale, the RATES report indicated that in 2003, there was no maize trade from Mbale to Kampala, and therefore the estimate of annual maize trade between the two areas is five (5) percent. The trade volume is therefore a product of the annual production and the various percentages shown in Figure 2. This calculation is expressed in equation (11) below.

(11) Export trade volume = Annual production * % Production * % Traded * % Traded with Kampala

Using the Masindi example, the volume of maize traded from Masindi to Kampala would be: 1,350,000 * 18% * 65% * 70% = 1,105,650 metric tonnes. Table 4 shows the estimated traded volumes from each of the supply markets to Kampala, the unit impact (from the least squares regression results in Table 3), and the derived economic impact (total revenue).

Table 4: Economic Impact of the MIS on the Maize Industry in Uganda

Supply Market	(1) Estimated export trade volume	(2) Unit impact [a]	(3) Revenue [b] (1)*(2)	(4) Δ in exports = 5% of total exports (1)	(5) Average price before the MIS	(6) Revenue (4)*(5) [d]	Total Revenue (3) + (6)
	('000 kg)	(UShs/Kg)	(US$) [c]	('000kg)	(UShs/kg)	(US$)[e]	(US$)
Masindi	110,565	8.906	508,622	5,528.25	197.8	755,693	1,264,315
Kasese	31,590	13.339	217,653	1,579.5	204.9	223,662	441,315
Mbale	10,091	7.133	37,180	504.55	218.5	76,188	113,368
Total	**152,246**		**763,455**			**1,055,544**	**1,818,999**

[a] MIS coefficients from Table 3

[b] Revenue = area (ABCF) in equation (9)

[c] US$ 1 = UShs 1,936 (Bank of Uganda, 2003/04)

[d] Revenue = area ($CDQ_{m2}Q_{m4} + EFQ_{m1}Q_{m3}$) in equation

(10)

[e] US$ 1= UShs 1,447 (Bank of Uganda, 1998/99)

The MIS resulted in US$ 1,818,999 being generated in revenue from additional trade from the three supply markets to Kampala in 2004. The economic impact is highest for trade between Masindi and Kampala because the survey reports indicate that the trade volume along that route is high, compared with the Kasese-Kampala and Mbale-Kampala trade routes. It follows that in other years, the revenue generated would depend on the amount of maize that is traded with Kampala from the three supply markets. The findings shown in Table 4 imply that as a result of the information service, traders earned more revenue by engaging in trade. The progress report on the MIS project, by Okoboi and Ferris (2000) revealed that the cost of disseminating the information by radio was US$ 17,000[7], which is equivalent to about two (2) percent of the estimated revenue benefits. The estimate does not indicate how the revenue was distributed between the Kampala traders and the traders in the three supply markets. In order to calculate the net benefits to the both sets of traders, various costs must be taken into account. For Kampala traders, the net benefit would be difference between the final price and the sum of the price at the various supply markets and the inter-market transfer costs. For traders at the three supply markets, the net benefit would be the difference between the respective market prices and the sum of the price of maize at farm-gate or from rural traders (depending on where the maize was procured), and the cost of transferring the maize from the procurement location to the respective markets.

4.0 Research implications, conclusions and areas for future research

[7] Report states that the cost was UShs 30,000,000 in 2000. Calculation in the text is made using a nominal exchange rate of US$1.00 = UShs 1,763 from the Bank of Uganda (2000/01)

The objective of this research was to assess the impact of the MIS on the performance of maize markets in Uganda using two empirical indicators – pricing efficiency and price transmission. The MIS positively impacted price performance in terms of an increased portion of price changes being transmitted further down the maize supply chain in all three market pairs. The speed of transmission of prices increased only in the case of the Kampala-Masindi market pair. The least squares model shows that the MIS has improved the level of efficiency.

4.1 Implications

Implications for Traders: Traders from three supply markets now receive higher prices than before the MIS was implemented. In addition, the reduction in the price difference after the MIS was implemented implies increased trading activity with Kampala, and therefore increased trade revenue of about US$ 1,818,999 per year.

Implications for Government: Increased trade revenue implies increased tax revenue for the government. In addition, increased trade implies a more efficient food distribution system. Food is more now efficiently transferred from areas of surplus to areas of excess demand. The increase in magnitude of price transmission implies that incomes are more equitably distributed than before the MIS was implemented.

Implications for Sponsors: The positive results of the MIS in terms of increased trade revenue, better food distribution systems, and higher prices for traders down the supply chain augur well for the current sponsors – the IITA Foodnet program and the UNFA. These results should give impetus for continued funding of the programme.

Impact on Consumers: The reduction in regional price difference implies that, holding all other factors constant, maize market prices for the final consumer in Kampala, are now lower than before the MIS was implemented. In addition, increased trade implies an increase in the food availability.

4.2 Conclusions and policy recommendations

It is important to recognize that these results are obtained from price-based tests, and therefore the conclusions in regard to trade are only implied. The general conclusion is that the MIS has positively impacted the four maize markets in this analysis. Larger shares of prices are being transmitted down the supply chain, and more revenue has been generated by increased trade. However, there exists substantial opportunity to make more profit by arbitraging from the Masindi and Kasese markets to Kampala.

Policy intervention should be directed in two areas. Firstly, there is need for continued support of the MIS programme from its current sponsors, the government or private traders, as there is evidence that price benefits are more evenly distributed. Secondly, in-country trade should be encouraged. One proposal would be to disseminate market analyses to traders through Traders' Associations to inform them of these revenue opportunities and encourage greater participation in trade. The priority locations for intervention are Masindi and Kasese, as the unit impacts from these two areas are highest.

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Appendix 1: An example of how to calculate variables for the Houck model

Weeks	$\mathbf{P_{j,t}}$	$\mathbf{\Delta P_{j,t}}$	$\sum_{t=0}^{m} \mathbf{\Delta P_{j,t}}$	$\mathbf{P_{i,t}}$	$\mathbf{\Delta P^{1}_{i,t}}$	$\sum_{t=0}^{m} \mathbf{\Delta P^{1}_{i,t}}$	$\mathbf{\Delta P^{11}_{i,t}}$	$\sum_{t=0}^{m} \mathbf{\Delta P^{11}_{i,t}}$
Week 1	10	0	0	6	0	0	0	0
Week 2	12	2	2	4	0	0	-2	-2
Week 3	9	-3	-1	5	1	1	0	-2
Week 4	15	6	5	7	2	3	0	-2
Weeks 5	12	-3	2	8	1	4	0	-2
Week 6	14	2	4	7	0	4	-1	-3
Weeks 7	14	0	4	6	0	4	-1	-4
Week 8	19	5	9	8	2	6	0	-4
Week 9	16	-3	6	10	2	8	0	-4
Week 10	18	2	8	9	0	8	-1	-5

$$\sum_{t=0}^{m} \Delta P_{j,t} = \sum_{t=0}^{m} a_1 \Delta P^{1}_{i,t} + \sum_{t=0}^{m} a_2 \Delta P^{11}_{i,t} \text{ .... Houck model}$$

$P_{j,t}$ Price at market *j*, at time *t*

$\Delta P_{j,t}$ Difference between price at time *t* and at time (*t-1*) at market *j*

$\sum_{t=0}^{m} \Delta P_{j,t}$ Summation of the price difference ($P_{j,t} - P_{j,t-1}$) at market *j*.

$P_{i,t}$ Price at market *i*, at time *t*

$\Delta P^{1}_{i,t}$ Price difference ($P_{i,t} - P_{i,t-1}$) at market *i*, if the difference is positive

$\Delta P^{11}_{i,t}$ price difference ($P_{i,t} - P_{i,t-1}$) at market *i*, if the difference is negative

$\sum_{t=0}^{m} \Delta P^{1}_{i,t}$ Summation of the price difference ($P_{i,t} - P_{i,t-1}$) at market *i* if the difference is positive

$\sum_{t=0}^{m} \Delta P^{11}_{i,t}$ Summation of the price difference ($P_{i,t} - P_{i,t-1}$) at market *i* if the difference is negative

Appendix 2a: Testing whether Kampala price changes "Granger cause" Masindi price changes*

Equation: $Masindi_t = \alpha_0 + \alpha_1 Masindi_{t-1} + \alpha_2 Masindi_{t-2} + \alpha_3 Kampala_{t-1} + \alpha_4 Kampala_{t-2} + \alpha_5 Kampala_{t-3} + \xi 1_t$

```
Linear regression                                   Number of obs =     545
                                                    F(  5,   539) =  469.69
                                                    Prob > F      =  0.0000
                                                    R-squared     =  0.9238
                                                    Root MSE      =  22.695
```

Masindi	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
Masindi_1	1.018295	.0566089	17.99	0.000	.9070944	1.129496
Masindi_2	-.127406	.0599986	-2.12	0.034	-.2452658	-.0095462
Kampala_1	.2038378	.0483033	4.22	0.000	.108952	.2987237
Kampala_2	-.0769351	.0580576	-1.33	0.186	-.1909819	.0371118
Kampala_3	-.0562832	.0500376	-1.12	0.261	-.1545757	.0420094
Constant	4.394795	3.995873	1.10	0.272	-3.454598	12.24419

* Variable definitions after Appendix 4.2f

F-test: H_0: Kampala_1= Kampala_2= Kampala_3=0

F(3, 539) = 6.07

Prob > F = 0.0005

Appendix 2b: Testing whether Masindi price changes "Granger cause" Kampala price changes

Equation: $Kampala_t = \beta_0 + \beta_1 Kampala_{t-1} + \beta_2 Kampala_{t-2} + \beta_3 Masindi_{t-1} + \beta_4 Masindi_{t-2} + \beta_5 Masindi_{t-3} + \xi 1_t$

```
Linear regression                                    Number of obs =     545
                                                     F(  5,   539) = 1417.83
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.9224
                                                     Root MSE      =  23.887

------------------------------------------------------------------------------
          |               Robust
Kampala   |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Kampala_1 |   .9441239    .054958    17.18   0.000     .8361658    1.052082
Kampala_2 |  -.0573948   .0564939    -1.02   0.310      -.16837    .0535804
Masindi_1 |    .324003   .0476539     6.80   0.000     .2303928    .4176132
Masindi_2 |  -.2353183   .0646705    -3.64   0.000    -.3623553   -.1082812
Masindi_3 |  -.0042253    .042107    -0.10   0.920    -.0869391    .0784886
 Constant |   12.93438   3.136289     4.12   0.000     6.773529    19.09522
-----------------------------------------------------------------------------
```

F-test: H_0: Masindi_1 = Masindi_2 = Masindi_3 = 0

F(3, 539) = 15.97

Prob > F = 0.0000

Appendix 2c: Testing whether Mbale price changes "Granger cause" Kampala price changes

Equation: $Kampala_t = \delta_0 + \delta_1 Kampala_{t-1} + \delta_2 Mbale_{t-1} + \delta_3 Mbale_{t-2} + \delta_4 Mbale_{t-3} + \xi 3_t$

```
Linear regression                                    Number of obs =     545
                                                     F(  4,   540) = 1525.51
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.9208
                                                     Root MSE      =  24.103

------------------------------------------------------------------------------
         |               Robust
 Kampala |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Kampala_1 |   .8918865   .0265667    33.57   0.000     .8396997    .9440733
  Mbale_1 |   .3379586   .0695105     4.86   0.000     .2014145    .4745027
  Mbale_2 |  -.2021586   .0885623    -2.28   0.023    -.3761274   -.0281898
  Mbale_3 |  -.0482406   .0625549    -0.77   0.441    -.1711213    .0746402
 Constant |   9.005423   3.174535     2.84   0.005     2.769472    15.24137
------------------------------------------------------------------------------
```

F-test: H_0: Mbale_1 = Mbale_2 = Mbale_3 = 0

F(3, 540) = 11.58

Prob > F = 0.0000

Appendix 2d: Testing whether Kampala price changes "Granger cause" Mbale price changes

Equation: $Mbale_t = \mu_0 + \mu_1 Mbale_{t-1} + \mu_2 Kampala_{t-1} + \mu_3 Kampala_{t-2} + \mu_4 Kampala_{t-3} + \xi 4_t$

```
Linear regression                                    Number of obs =     545
                                                     F(  4,   540) = 1521.20
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.9384
                                                     Root MSE      =  19.392
```

Mbale	Robust Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Mbale_1	.9499824	.0205025	46.33	0.000	.9097079	.9902569
Kampala_1	.1277557	.0463202	2.76	0.006	.0367659	.2187455
Kampala_2	-.1097802	.056769	-1.93	0.054	-.2212954	.0017349
Kampala_3	-.002229	.0440791	-0.05	0.960	-.0888166	.0843586
Constant	7.696446	2.702583	2.85	0.005	2.387581	13.00531

F-test: H_0: Kampala_1 = Kampala_2 = Kampala_3 = 0

F(3, 540) = 2.56

Prob > F = 0.0542

Appendix 2e: Testing whether Kasese price changes "Granger cause" Kampala price changes

Equation: $Kampala_t = \theta_0 + \theta_1 Kampala_{t-1} + \theta_2 Kampala_{t-2} + \theta_3 Kampala_{t-3} + \theta_4 Kasese_{t-1} + \theta_5 Kasese_{t-2} + \theta_6 Kasese_{t-3} + \xi 5t$

```
Linear regression                                 Number of obs =     545
                                                  F(  6,   538) =  995.25
                                                  Prob > F      =  0.0000
                                                  R-squared     =  0.9186
                                                  Root MSE      =  24.486
```

Kampala	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
Kampala_1	.9937418	.056355	17.63	0.000	.8830389	1.104445
Kampala_2	-.1196284	.0813454	-1.47	0.142	-.2794219	.0401652
Kampala_3	.0356006	.0561295	0.63	0.526	-.0746592	.1458604
Kasese_1	.1296084	.0645993	2.01	0.045	.0027106	.2565062
Kasese_2	.0042059	.0971695	0.04	0.965	-.1866723	.1950841
Kasese_3	-.0743575	.0556952	-1.34	0.182	-.1837642	.0350491
Constant	11.8843	3.286092	3.62	0.000	5.429153	18.33944

F- test: H_0: Kasese_1 = Kasese_2 = Kasese_3=0

$F(3, 538) = 5.50$

Prob > F = 0.0010

Appendix 2f: Testing whether Kampala price changes "Granger cause" Kasese price changes

Equation: $Kasese_t = \lambda_0 + \lambda_1 Kasese_{t-1} + \lambda_2 Kasese_{t-2} + \lambda_3 Kampala_{t-1} + \lambda_4 Kampala_{t-2} + \lambda_5 Kampala_{-3} + \xi 6t$

```
Linear regression                                     Number of obs =     545
                                                      F(  5,   539) =  309.15
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.8562
                                                      Root MSE      =  32.673
----------------------------------------------------------------------------
             |               Robust
   Kasese |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+--------------------------------------------------------------
 Kasese_1 |   .7501458   .1367542     5.49   0.000     .4815092    1.018782
 Kasese_2 |   .0899165   .1105729     0.81   0.416    -.1272901    .3071232
Kampala_1 |   .2471784   .0894047     2.76   0.006      .071554    .4228028
Kampala_2 |  -.0629537   .0994528    -0.63   0.527    -.2583164     .132409
Kampala_3 |  -.0673144    .049288    -1.37   0.173    -.1641345    .0295056
 Constant |   3.536061    4.71917     0.75   0.454    -5.734157    12.80628
```

F-test: H_0: Kampala_1 = Kampala_2 = Kampala_3 = 0

F(3, 539) = 4.66

Prob > F = 0.0032

Variable Definitions

Name	Definition
Kampala	Kampala price at time t
Masindi	Masindi price at time t
Mbale	Mbale price at time t
Kasese	Kasese price at time t
Kampala_i	Kampala price lagged by week i, where i = 1, 2, 3
Masindi_i	Masindi price lagged by week i, where i = 1, 2, 3
Mbale_i	Mbale price lagged by week i, where i = 1, 2, 3
Kasese_i	Kasese price lagged by week i, where i = 1, 2, 3

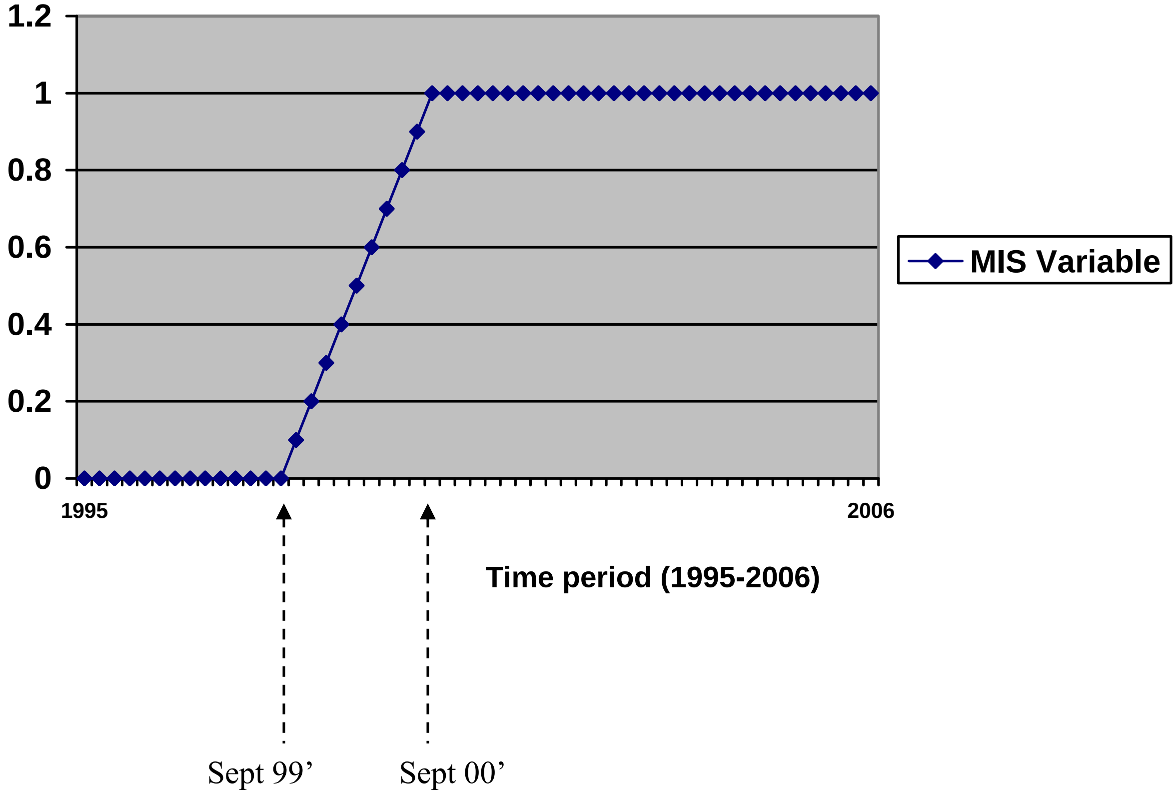
Appendix 3: Calculation of Inter-Market Transfer cost

Time period	Fuel price (1)	Transport cost (2)	Transport CPI (3)	Non-transport cost (4)	Inter-market transfer cost
Week 1	A_1	B_1	C_1	D_1	$B_1 + D_1$
Week 2	A_2	B_2	C_2	D_2	$B_2 + D_2$
Week 3	A_3	B_3	C_3	D_3	$B_3 + D_3$
Week 4	A_4	$\mathbf{B_4}$	C_4	$\mathbf{D_4}$	$B_4 + D_4$
Week 5	A_5	B_5	C_5	D_5	$B_5 + D_5$
Week 6	A_6	B_6	C_6	D_6	$B_6 + D_6$
Week 7	A_7	B_7	C_7	D_7	$B_7 + D_7$
Week 8	A_8	B_8	C_8	D_8	$B_8 + D_8$
Week 9	A_9	B_9	C_9	D_9	$B_9 + D_9$
Week 10	A_{10}	B_{10}	C_{10}	D_{10}	$B_{10} + D_{10}$

Notes:

1. Data on fuel price (1) and transport CPI (3) are obtained from the Statistical Abstracts (UBOS)
2. Taking week 4 as the week when the survey was taken, B_4 and D_4 are unit estimates for transport and non-transport costs reported in the survey.
3. Calculation of B_i and D_i (except B_4 and D_4)
   i. $B_i = B_4 + \left(\frac{A_i - A_4}{A_4}\right)$
   ii. $D_i = D_4 + \left(\frac{C_i - C_4}{C_4}\right)$

Appendix 4: Representation of the MIS variable



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