On Market Liberalisation and Efficiency: A Structural VECM Analysis of Dry Beans Markets in Malawi

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Abstract

Economic theory predicts positive effects of market liberalisation on market efficiency and integration. This paper investigates the effects of liberalisation on dry beans markets systems in Malawi. It also investigates the nature of structural relationships existing within each market system. The analysis relies on structural vector equilibrium correction models (SVECM). The results suggest that dry beans markets in Malawi are integrated and markets within the Southern region market system share stronger links in the short-run than those in other regions of Malawi. The analysis also reveals that peripheral markets drive prices in central markets.

Keywords: *Malawi, market liberalisation, market efficiency, market integration, developing countries.*

JEL Classifications*: Q11, Q13, Q18*

1. Introduction

The analysis of spatial markets is often associated with two key concepts: “market efficiency” and “market integration”. In this analysis, market efficiency is the ability of markets to transmit price signals between each other, and market integration is the interdependence of markets, across time and space. The former is believed to be

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facilitated by market liberalisation, the later by market efficiency. The objective of the study is to investigate whether dry beans markets in Malawi are spatially integrated, and to analyse their extent of integration within the context of market liberalisation.

This paper is organized as follows: Section 2 provides a brief review of relevant literature. Section 3 presents the methodology. Section 4 briefly describes the data. Section 5 discusses the results. Section 6 concludes the analysis.

2. Brief literature review

The spatial arbitrage theory forms the basis of most analyses on spatial market behaviour. In spatial arbitrage, prices of homogeneous goods in spatial markets differ only by the magnitude of transaction costs and a profit margin. The test of spatial arbitrage requires information on trade flows between markets, transaction costs and prices. However, historically, spatial market integration has been measured within the framework of spatial price equilibrium (SPE). The SPE framework involves modelling inter-market price linkages in the point-space tradition of Samuelson (1952) and Takayama and Judge (1964). Later however, the comovement of prices in spatially separated markets became the standard choice in market analysis (Barrett, 1996). Price comovement was preferred because empirically, only price information is usually readily available to the analyst. Variants of the price co-movement approach include: correlation analysis (e.g. Jones, 1972; and Lele, 1967); the Law of One Price (LOP) (e.g. Richardson, 1978); distributed lag model (Ravallion, 1986); Cointegration and Granger-causality (Palaskas & Harriss-White, 1993; and Alexander & Wyeth, 1994). This paper indirectly analyses the fulfilment of the spatial arbitrage condition using a systems approach. The systems approach, though similar to the price comovement approach, is based on identifying the strength of canonical correlations between relative price vectors in spatial markets. These approaches ignore the role of transaction costs in price transmission. Consequently, they assume linear relationships between markets, an assumption that might not be consistent with discontinuities in trade implied by the spatial arbitrage condition (Baulch, 1997b). For the sake of brevity, extensions of the linear model are not explored in this paper.

The drive towards testing the theoretical predictions of market liberalisation has been initiated by two factors: firstly, the realisation that most developing countries, Malawi inclusive, have in the recent past restructured their economies and moved towards full liberalisation; and secondly, the fact that the dry beans market in Malawi has exclusively remained free from regulation from time immemorial. That is, the past four or so decades have witnessed significant evolution of economic and trade policy in developing countries. These have been driven by various negative internal and external shocks. For Malawi, the dominant development strategy prior to 1987 was 'an export led development strategy'. Through this strategy, government regulated both the production and marketing of agricultural commodities. In the late 1970s and early 1980s, Malawi was hit by twin crises: the global economic and financial crisis due to the second oil crisis of 1979; and the Mozambican civil war. These led to deterioration of the country's terms of trade (ToT), and macroeconomic instability (Lele, 1989). In response, government in 1981 adopted structural adjustment programmes (SAPs) under the auspices of the World Bank (WB) and International Monetary Fund (IMF). The SAPs involved removing price distorting official barriers to trade and adopting free trade principles (Dean, *et al.,* 1985). By 1987, production and marketing of most of the formerly controlled crops had been liberalised. By 1995, the whole agriculture sector had been fully liberalised (World Bank, 1997). However, the fact that the dry beans market has been excluded from all forms of market regulation, despite dry beans being the second most important grain legume crop in Malawi, is an interesting, and important salient feature for this market. Considering that economic theory predicts positive effects of liberalisation on market efficiency and market integration, this feature provides a unique opportunity for testing these predictions. This is particularly inviting considering that Malawi, like most developing economies, is still facing many structural challenges, such as poor infrastructure, weak legislation and institutions, which may undermine the expected outcomes of liberalisation.

3. Methodology

In this study, markets have been constituted into market systems based on the country's regional boundaries. This achieves two things. First, it ensures the generation of comprehensive and efficient information about market behaviour within a particular region. Second, it circumvents the dimensionality problem associated with vector auto-regressive (VAR) models. The analysis of each system is based on two assumptions: (i) that two or more vectors share a common stochastic path in the long-run. They have stable long-run cointegration vectors (i.e. $\beta' x_t$) that link them; and (ii) that economic agents are rational. They utilise all information available to them before investing. This implies that the theoretical cointegration model is well behaved. It has no noise and heteroscedasticity (Hendry, *et al.,* 1994).

Related studies, such as Chirwa (2001) apply a multivariate systems approach in testing the reduced rank hypothesis, and a univariate approach to model the short-run dynamics in the second stage of the analysis. Chirwa (2001) compares the level of integration of selected commodity markets in Malawi between pre- and post-reform eras, and finds that commodity markets in Malawi are integrated. However, his approach relies on assumptions about the exogeneity of some price vectors in order to produce meaningful results. Empirically, it is usually almost impossible to ascertain the exogeneity of price vectors, which compromises the validity of results. Our point of departure is that, unlike Chirwa (2001), we model feedback mechanisms between relative price vectors in spatial market systems in the post-reform era. This approach does not have to depend on any exogeneity assumptions. It simply requires the analyst to model feedback behaviour between relative price vectors, and to capture the relative strength of their canonical correlations. Our approach is more efficient and informative as it also allows the modelling of both structural and instantaneous causality relationships between vectors within the same framework, and ours is also data driven. The analysis covers sixteen spatial markets across Malawi, five from the Northern region (Chitipa, Karonga, Rumphi, Mzuzu and Mzimba), another five from the Central region (Lilongwe, Chimbiya, Mitundu, Mchinji, and Lizulu) and six from the Southern region (Lunzu, Liwonde, Mangochi, Ntaja, Limbe, Bvumbwe and Luchenza). The results for the Central region model are not discussed in this paper due to space limitations but are available upon request.

The first step of the modelling process involves formulating and estimating a well-behaved, restriction free p^{th} order, K-dimentional reduced form (URF) model of the system (equation (1)):

$$y_t = \pi_1 y_{t-1} + \Phi q_t + \Gamma_1 z_t + v_t \quad (1)$$

where $v_t \sim IN[0, \Omega]$ and y_t and z_t are $n\,x\,1$ and $q\,x\,1$ vectors of actual observations (i.e. price vectors) at time t, for $t = 1, \dots\dots, T,$ on the dependent variables y and independent variables z. The number of variables involved determines the dimension K, of the system. y_t and z_t are indices of price vectors in each system and q_t includes the deterministic components (constant and trend) of the model. The parameters, π_1, Φ, Γ_1 and Ω are our parameters of interest, and are assumed to be constant and non-variant.

The second step involves mapping equation (1) into an equilibrium correction model (ECM) (i.e. equation (2)), and using it to test the reduced rank hypothesis ($H_{(p)}: rank(\pi) \leq r$) test.

$$\Delta y_t = \Pi y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \Phi q_t + v_t \quad (2)$$

This is a Johansen's test equation, in which π is the matrix of long-run responses that determines how the log-levels of the process, y_t enter the system. This is synonymous to finding the number of linear combinations of vectors that are stationary, I(0). The $\pi - \text{matrix}$ can be decomposed into $K\,x\,r$ dimensional loading matrices, α; and long-run matrices, β; such that $\pi = \alpha\beta'$.

The third step involves identifying α and β by testing various restrictions on them using likelihood ratio (LR) tests, a maximum likelihood (ML) approach. Identifying α and β delivers economically meaningful structural cointegration relationships (Johansen, 1995b). The resulting restricted model of the system is of the form:

$$\Delta y_t = \alpha\beta^{*\prime} y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \Phi q_t + \xi_i D_t + v_t \quad (3)$$

where: $\Sigma = [vv']$, $\alpha\beta^{*\prime}$ captures long-run dynamics of the data; Γ_j short-run dynamics; Φ effects of deterministic components; and ξ_i effects of unusual occurrences in the economy. The only missing pieces of information in equation 3 are contemporaneous variables, which capture the instantaneous effect of some of the vectors on the system. Contemporaneous variables are determined is step four by decomposing the correlation matrix of the system. Since the analysis is data driven, the decomposition of the empirical correlation matrix is preferred to the Cholesky decomposition, when coming up with the lower triangular matrix. Tetrad 4 is used for this purpose, and to graphically search for causal relationships. If Tetrad 4 fails to conclusively determine the direction of causality, information criteria (Akaike or Schwarz) are used to determine the dominant model from candidate models.

The fifth step involves sequentially trimming insignificant variables from the final model, nesting all candidate models, and selecting a specific system that best fits the data based on the acceptability of the nested model, and information criteria. The objective is to come up with a parsimonious structural VECM model, and reduce the sample dependence of the estimated model that may arise due to the high dimensionality of VAR models. It also increases the stability of the model (Hendry & Doornik, 1994). Finally, model (3) is nested into model (4) and short-run, long-run and contemporaneous coefficients ($\tilde{\alpha}^*$, $\tilde{\beta}^{*'}$, $\tilde{\Gamma}_j^*$ and $\tilde{\Phi}^*$) simultaneously calculated and used for inference.

$$\Delta y_t = \tilde{\alpha}^*(\tilde{\beta}^{*'} y_{t-1}) + \sum_{j=1}^{p-1} \tilde{\Gamma}_j^* \Delta y_{t-j} + \tilde{\Phi}^* q_t + \xi_i D_t + \varepsilon_t \tag{4}$$

Where, $\varepsilon_t \sim IN(0, \Omega)$ and $\tilde{\beta}^*$, is a lower triangular matrix, and Ω is a diagonal variance-covariance matrix. The parameters of interest are the structural coefficients $\tilde{\Phi}^*, \tilde{\alpha}^*$ and $\tilde{\Gamma}_j^*$; for $j = 1, 2, \dots \dots, p-1$.

4. Data

This analysis uses monthly averages of weekly price observations collected by Malawi's Ministry of Agriculture and Food Security (MoAFS). Table 1 below presents the descriptive statistics for nominal price observations and first differences. The variables are defined in table 9 in annex 1. The data is deflated using the Consumer Price Index

(CPI) at 2000 constant prices, and log-transformed prior to the analysis. The use of monthly averages is favoured to weekly observations to avoid instances where prices are constant across markets for relatively long time lags. This may invalidate statistical analyses that are based on assumptions of independently and identically continuously distributed observations (Baulch, *et al.*, 2008). Data on trade volumes, transactions costs and number of traders in the market was not available for the analysis. Monthly observations also provide ample time lags for prices to adjust, and commodity transfers to occur.

Table 1: Descriptive statistics (Nominal monthly observations) for selected markets

Market	$\overline{x}$	$s_{\overline{x}}$	Skew	Ex. Kurt.	Jarq. Bera	min	max
cp_t	87.22	55.91	0.59	-0.80	12.21	15.84	236.60
ka_t	111.70	68.44	0.43	-1.13	12.17	17.52	289.01
ru_t	114.14	56.95	0.73	-0.40	13.72	32.96	291.39
mz_t	104.47	59.78	1.19	0.36	34.93	37.72	268.75
mzi_t	127.82	82.54	0.50	-1.38	17.60	29.53	300.00
luz_t	109.55	61.07	0.52	-0.89	10.99	23.03	272.79
liw_t	135.43	87.03	0.60	-1.09	15.51	33.64	327.39
mgh_t	126.60	78.56	0.47	-1.15	12.98	17.32	275.57
$ntja_t$	136.69	89.74	0.65	-1.28	19.34	27.34	312.23
le_t	162.02	54.74	0.05	-0.92	3.60	61.70	294.12
bvu_t	154.59	50.38	0.28	-0.92	76.49	6.92	275.00
$luch_t$	152.97	48.02	-0.10	-1.04	5.61	69.50	264.00
Dcp_t	0.005	0.140	-0.45	2.12	31.27	-0.516	0.439
Dka_t	0.011	0.148	-0.36	1.45	15.48	-0.52	0.41
Dru_t	0.006	0.109	-0.24	0.31	1.94	-0.30	0.27
Dmz_t	0.005	0.152	0.45	1.07	11.45	-0.43	0.58
Dle_t	0.009	0.152	0.90	4.16	25.18	-0.44	0.69
$Dbvu_t$	0.005	0.094	0.449	0.60	3.72	-0.21	0.32
$Dluch_t$	0.009	0.099	-0.93	1.89	10.97	-0.32	0.21
$Dmzi_t$	0.005	0.107	0.19	0.59	2.84	-0.26	0.35
$Dluz_t$	0.007	0.158	-0.48	3.37	72.24	-0.65	0.55

$Dliw_t$	0.004	0.148	-0.48	3.05	59.94	-0.67	0.36
$Dmgh_t$	0.006	0.152	-1.39	7.62	386.09	-0.87	0.47
$Dntja_t$	0.006	0.104	0.72	2.24	41.62	-0.28	0.41

In table 1, the last seven markets (Southern region) have the highest relative average prices. The mean is calculated as $\bar{x} = \frac{1}{T}\sum_{t=1}^{T} x_t$ and standard deviation as $s = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(x_t - \bar{x})^2}$). Skewness, excess kurtosis and Jarque-Bera columns capture the distributional shape of the data. All price vectors have positive skewness and excess kurtosis in levels, suggesting that the data is not normally distributed in levels, but relatively normally distributed in first differences. This affects the distributional density of the data in two ways: firstly, it causes the empirical density function of some of the vectors to have longer tails on either sides, compared to normal densities; and secondly, the empirical densities of log levels is characterised by two peaks *(see annex 2)*. However, differencing removes the peaks and approximates the density distribution to a normal distribution. The order of integration of the data is formally tested using the Augmented Dickey Fuller (ADF) approach (equation 5).

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \sum_{i=2}^{p} \beta_i \, \Delta Y_{t-i+1} + \varepsilon_t \qquad (5)$$

where; $\gamma = -(1 - \sum_{i=1}^{p} \alpha_i)$, $\beta = -\sum_{j=i}^{p} \alpha_j$ and p is the lag order of the equation. The unit root test results are presented in table 10 in annex 3. The results confirm that the data is I(1) in log-levels, and I(0) in first differences.

5. Results and Discussion

5.1. Formulation and Estimation of General Unrestricted Systems (GUM)

The lag order analysis selects a 2nd and 3rd order VAR model for Northern and Southern region market systems, respectively. Further testing of each system indicates that a trend is statistically significant to each system. The misspecification test results for each GUM are presented in tables 2 and 3 below. According to table 2, there is no serial correlation in the Northern region system but in the Rumphi equation (at 1% level of significance) in the full model (i.e. VAR(13)). Also, there are heteroscedasticity and ARCH residuals in the Mzuzu equation.

Table 2: Misspecification tests for equations of the Unrestricted VAR(2)

Test		cp_t	ka_t	ru_t	mz_t	mzi_t
AR (1-2)	**F(2,129)**	**0.729**	**0.262**	**0.958**	**0.664**	**0.102**
		[0.484]	[0.770]	[0.387]	[0.517]	[0.903]
AR (1 -13)	**F(13,118)**	**0.769**	**1.496**	**2.357**	**0.564**	**1.188**
		[0.692]	[0.129]	[0.008]**	[0.878]	[0.297]
ARCH (1 -13)	**F(13,117)**	**1.735**	**0.538**	**1.563**	**2.386**	**0.964**
		[0.062]	[0.897]	[0.106]	[0.007]**	[0.491]
Normality	x^2 **(2)**	**5.071**	**4.161**	**2.404**	**0.671**	**3.511**
		[0.079]	[0.125]	[0.301]	[0.715]	[0.173]
Hetero	**F(22,120)**	**1.559**	**0.756**	**0.832**	**2.738**	**1.362**
		[0.068]	[0.773]	[0.682]	[0.000]**	[0.148]

***significant at 1%, *significant at 5%*

Table 3 indicates that the null of no autocorrelation can be rejected in the Bvumbwe equation (at 5%) in the VAR(3) model, and the Liwonde and Ntaja equations in the VAR(13) model at 5% level. There is heteroscedasticity in the Limbe (i.e. at 1%) and Luchenza equations (i.e. at 5%). Normality is only rejected in the Bvumbwe and Liwonde equations at 5% level of significance.

Table 3: Misspecification tests for equations of the Unrestricted VAR(3)

Test		le_t	bvu_t	liw_t	$luch_t$	mgh_t	$ntja_t$
AR (1-3)	**F(3,56)**	**1.631**	**3.350**	**2.016**	**0.583**	**1.057**	**0.578**
		[0.193]	[0.025]*	[0.122]	[0.629]	[0.375]	[0.632]
AR (1 -13)	**F(13,46)**	**1.360**	**2.094**	**2.465**	**1.264**	**1.081**	**1.963**
		[0.216]	[0.033]*	[0.012]*	[0.269]	[0.398]	[0.047]*
ARCH (1 -13)	**F(13,53)**	**0.870**	**0.714**	**1.629**	**1.618**	**1.840**	**0.844**
		[0.588]	[0.741]	[0.106]	[0.109]	[0.061]	[0.614]
Normality	**x^2 (2)**	**5.262**	**6.368**	**8.033**	**1.586**	**2.183**	**3.172**
		[0.072]	[0.041]*	[0.018]*	[0.453]	[0.334]	[0.205]
Hetero	**F(30,40)**	**2.485**	**1.179**	**1.165**	**1.960**	**0.964**	**0.761**
		[0.003]**	[0.303]	[0.317]	[0.019]*	[0.544]	[0.800]

***significant at 1%, *significant at 5%*

In terms of the overall performance of the models, both Northern and Southern region market systems are satisfactorily well behaved.

5.2. Cointegration Analysis of VAR Systems

The results of reduced rank hypothesis (RRH) tests (table 4) are compared between CPI deflated, and nominal price data to check whether the long-run dynamic behaviour of deflated data is different from non-deflated data. The associated time series graphs of cointegration vectors are presented in annex 3. Systems formulated from deflated data seem to be relatively less integrated than those from nominal data. However, they are consistent with the theoretical behaviour of dry beans markets in Malawi. For nominal data, the northern region system has two cointegrating vectors while the southern region market system has three. In contrast, for the deflated data, northern and southern region market systems have two cointegrating vectors each. The analysis proceeds with deflated data because it is consistent with our theoretical expectations.

The identified stationary vectors for the northern region market system are : $3.96cp_t + mz_t - 4.76mzi_t + 3.66ru_t - ka_t$ is $I(0)$ and $mz_t - 0.52mzi_t - ru_t + 0.98ka_t - 0.0076trend_t$. The first vector has a time trend, but not the second vector.

Table 4: Comparative Analysis of Extent of Market Integration across Regions of Malawi

Deflated data			*non-deflated data*	
$H_0: rank(\pi) \leq r$	**North**	**South**	**North**	**South**
0	112.07**	153.56**	108.91**	245.97**
1	66.890*	94.324*	68.003*	152.04**
2	34.536	60.348	32.189	88.985**
3	18.292	33.969	15.646	41.643
4	6.834	16.829	4.0816	11.267
5	-	5.0037	-	3.9385

***significant at 1%, *significant at 5%*

The first vector suggests that when Mzuzu and Karonga prices are in equilibrium, Chitipa and Rumphi prices are simultaneously rising while Mzimba prices are falling. The second vector suggests that when Mzuzu and Rumphi prices are in equilibrium, Mzimba prices are falling while Karonga prices are rising. All this happens within the same time period.

Similarly, $le_t - 0.84bvu_t + 0.41liw_t - luch_t + 0.9mgh_t - 0.35ntja_t$ and $2.74\text{bvu}_t + liw_t - 3.2luch_t + 2.23mgh_t - ntja_t - 0.014trend_t$ are $I(0)$ for the Southern region market system. The first vector suggests that Limbe and Luchenza markets are in equilibrium when Liwonde and Mangochi prices are rising, and Bvumbwe and Ntaja falling. The second vector indicates that when Liwonde and Ntaja market prices are in equilibrium, Bvumbwe and Mangochi prices are rising, and Luchenza prices are falling.

5.3. Determination of Instantaneous Causality Relationships

5.3.1. Instantaneous Causality Structure for Northern Region Markets

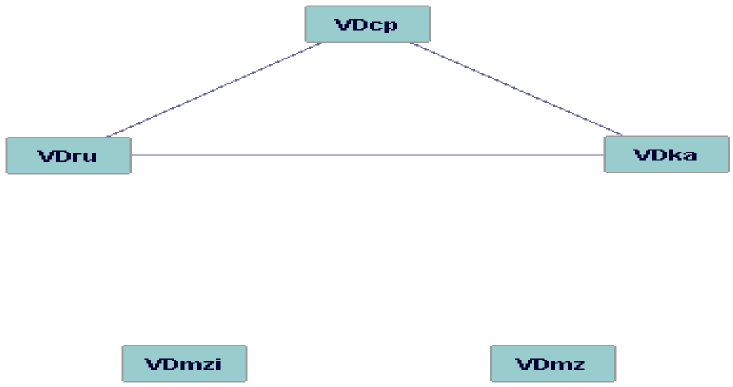
The PC algorithm finds a cyclic structural relationship between Chitipa[3], Karonga and Rumphi markets at 10% level of significance (figure 5.1). Mzuzu and Mzimba markets are outside this structural relationship. The direction of causality is not clearly

3

VDcp stands for residuals for Chitipa market; VDka, Karonga; Vdru, Rumphi; VDmz, Mzuzu and VDmzi, Mzimba.

revealed by the graphical search process, and is therefore determined using information criteria (table 5).

Figure 5.1: Contemporaneous Correlation Structure for Northern Region Markets



Causal structure, PC algorithm, (10%)

According to table 5, Schwarz, Hannan-Quinn and Akaike information criteria select the model in which Chitipa and Karonga are incorporated to the Rumphi model as contemporaneous explanatory variables and Chitipa to Rumphi model as a contemporaneous variable (matrix 1, annex 5). In this analysis SC is calculated as; $log\hat{\sigma}^2 + k(log\ T)/T$; HQ as $log\hat{\sigma}^2 + 2k(\log(log\ T))/T$ and AIC as $log\hat{\sigma}^2 + \frac{2k}{T}$.

Table 5: Results of causal structure tests for Northern region markets system

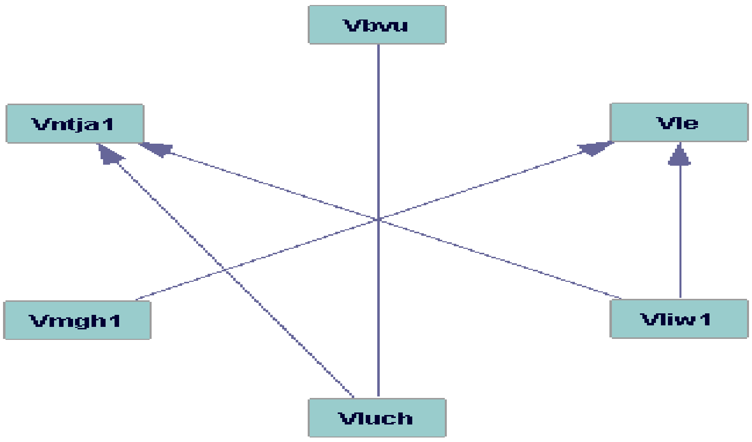
Model	SC	HQ	AIC
Dcp_t & Dka_t--> Dru_t; Dcp_t--> Dka_t	-6.258<	-6.529<	-6.714<
Dru_t & Dka_t--> Dcp_t;	-6.229	-6.487	-6.664
Dcp_t & Dru_t--> Dka_t;	-6.238	-6.496	-6.673

The acceptability of the final model was tested using a likelihood ratio (LR) test of over-identifying restrictions. It follows a χ^2 distribution, and has 18 degrees of freedom [i.e. $\chi^2(18)$]. The test statistic is given as 19.03, and the associated probability value is 0.3899. This suggests the system is not rejected.

5.3.2. Instantaneous Causality Structure for Southern Region Markets

Figure 5.2 (Southern region system) clearly indicates the direction of causality for all vectors, except for Luchenza and Bvumbwe markets. Liwonde causes Ntaja and Limbe (i.e. $Dliw_t$ –> $Dntja_t$ & Dle_t); Luchenza causes Ntaja ($Dluch_t$--> $Dntja_t$); and Mangochi causes Limbe ($Dmgh_t$ --> Dle_t). The direction of causality for Luchenza and Bvumbwe is determined using information criteria (table 6).

Figure 5.2: Contemporaneous Causality Structure for Southern Region Markets



Causal structure, PC (10%)

According to table 6, Bvumbwe causes Luchenza, and is added as a contemporaneous explanatory variable to the Luchenza equation (see matrix 2, annex 5).

Table 6: Results of causal structure tests for Southern region markets system

Model	SC	HQ	AIC
$Dbvu_t$ --> $Dluch_t$	-10.132<	-10.905<	-11.421<-
$Dluch_t$--> $Dbvu_t$	-10.010	-10.783	-11.300

5.4. Parsimonious Structural Vector Equilibrium Correction Models (PSVECM)

5.4.1. The model for the Northern region market system

Tables 7 and 8 present final parsimonious structural VEC models. For the Northern region model (table 7), the Mzuzu central market is the principal market. It has four peripheral markets; Rumphi, Mzimba, Karonga and Chitipa. Rumphi and Mzimba are the nearest peripheral markets, while Chitipa and Karonga are about 350km and 250km away from Mzuzu. However, there are good trade links between Chitipa, Karonga and Mzuzu. For individual equations, the Mzuzu equation suggests that Mzimba prices marginally influence Mzuzu prices. In contrast, the Mzuzu market increases both Karonga and Mzimba prices within a one month period lag. The equilibrium correction term (ECT) for the Mzuzu equation is the most important price driver in this system. It is adjusting at the speed of 15% per month towards the long-run equilibrium. Also, table 8 indicates that both Chitipa and Karonga have a contemporaneous effect on Rumphi prices, and that Chitipa prices also contemporaneously affect Karonga prices. The magnitude of effect of both Chitipa and Karonga on Rumphi is generally mild. Statistically, both contemporaneous variables are significant at 5% level of significance, and their effect is such that if both Chitipa and Karonga markets were hit by a price shock, about 16% and 13% of the respective shocks would be transmitted to the Rumphi market instantaneously. In contrast, 23% of the price shock hitting Chitipa would be instantaneously transferred to the Karonga market. The contemporaneous effect of Chitipa on Karonga is significant at the 1% level of significance.

Table 7: Structural Vector Equilibrium Correction Model for Northern Region Markets

Variables	Δcp_t *coeff*	Δmz_t *coeff*	Δmzi_t *coeff*	Δru_t *coeff*	Δka_t *coeff*
Constant	**0.806**	**0.456**	**0.114**	**-0.068**	**0.383**
	(0.000)	(0.002)	(0.288)	(0.606)	(0.008)
Δcp_{t-1}	**0.288**	---	---	---	---
	(0.000)				
Δru_{t-1}	---	---	---	---	---
Δmz_{t-1}	---	**-0.145**	**0.107**	---	**0.109**
		(0.083)	(0.086)		(0.183)
Δmzi_{t-1}	**-0.435**	---	**-0.117**	**-0.112**	---
	(0.000)		(0.170)	(0.192)	---
Δka_{t-1}	---	---	----	----	---
$ECT1_{t-1}$	**-0.054**	---	---	**-0.024**	---
	(0.000)			(0.002)	
$\mathrm{ECT2}_{t-1}$	**-0.089**	**-0.152**	**-0.036**	**0.107**	**-0.126**
	(0.028)	(0.002)	(0.313)	(0.002)	(0.001)
Δcp_t	---	---	---	**0.157**	**0.226**
				(0.021)	(0.008)
Δka_t	---	---	---	**0.126**	---
				(0.036)	

Notes: *The bolded numbers are coefficients of equations of each model. Their corresponding p-values for the test of significance are in parenthesis; ECT stands for equilibrium correction term.*

For the Chitipa market equation, Mzimba decreases Chitipa prices. A 10% increase in Mzimba prices in the previous month decrease Chitipa prices by about 4%. Past prices for Chitipa increase current prices. A 10% increase in the previous month increases current prices by about 3%. Both effects are significant at 1% level of significance. However, considering the distance between the two markets, it would be difficult to justify the effect of Mzimba prices on Chitipa prices. Price information alone cannot adequately explain this effect.

5.4.2. The model for the Southern region market system

The Limbe central market (Δle_t) is the principal market for the Southern region market system (table 8). The Limbe market is contemporaneously correlated with the Liwonde market. Any shock that hits the Liwonde market is instantaneously transferred to the Limbe market. If the Liwonde market was hit by a price shock, about 35% of that shock would be instantaneously transferred to Limbe. The Liwonde market also increases Limbe prices with a time lag. A 10% increase in Liwonde prices in the previous month increases Limbe prices by about 3%. The Limbe market is also influenced by Ntaja market prices. The Ntaja market decreases Limbe prices. A 10% increase in Ntaja prices decreases Limbe prices by 4%. Also, according to table 8, Liwonde is contemporaneously related to Ntaja. If the Liwonde market was hit by a price shock, 22% of that shock would be instantaneously transferred to the Ntaja market. The Ntaja market is also driven by Bvumbwe, Limbe and Liwonde markets. Bvumbwe prices decrease Ntaja prices, while Limbe prices increase them. A 10% increase in Bvumbwe prices in the previous month decreases Ntaja prices by 2%. A 10% increase in Limbe prices in the previous month increases Ntaja prices by 1%. If Ntaja prices increased by 10% in the previous month, this would increase current prices by 4%. Also, a 10% increase in Bvumbwe market prices in the previous two months reduces Ntaja prices by 3%. In contrast, a similar increase in Liwonde prices in the previous two months increases Ntaja prices by 3%. In table 8, Luchenza market is contemporaneously correlated to Bvumbwe market. If a price shock hit Bvumbwe, about 40% of the shock would be instantaneously transferred to Luchenza market. Ntaja prices also affect Luchenza market. A 10% rise in Ntaja prices in the previous two months increases Luchenza prices by 4%.

Table 8: Structural Vector Equilibrium Correction Model for Southern Region Markets

Variables	Δle_t *coeff*	Δbvu_t *coeff*	Δliw *coeff*	$\Delta luch_t$ *coeff*	Δmgh_t *coeff*	$\Delta ntja_t$ *coeff*
Constant	**0.279**	**0.468**	**0.160**	**-0.634**	**0.239**	**-0.178**
	(0.000)	(0.002)	(0.294)	(0.000)	(0.232)	(0.125)
Δbvu_{t-1}		**0.427**	---	---	**0.606**	**-0.155**
		(0.001)			(0.000)	(0.075)
Δbvu_{t-2}	---	**0.203**	**0.170**	**0.114**	---	**-0.275**
		(0.111)	(0.180)	(0.319)		(0.004)
Δle_{t-1}	**0.150**	**0.121**	**0.110**	**0.119**	---	**0.120**
	(0.137)	(0.088)	(0.065)	(0.157)		(0.022)
Δle_{t-2}	---	---	---	---	**-0.140**	---
					(0.103)	
Δliw_{t-1}	**0.309**	**-0.146**	---	---	**-0.364**	---
	(0.054)	(0.175)			(0.008)	
Δliw_{t-2}	---	---	---	---	---	**0.253**
						(0.002)
$\Delta ntja_{t-1}$	**-0.366**	---	---	---	**0.238**	**0.386**
(0.054)					(0.212)	(0.000)
$\Delta ntja_{t-2}$	---	---	---	**0.414**	**0.249**	---
				(0.000)	(0.173)	
Δmgh_{t-1}	---	---	---	---	**-0.222**	---
					(0.076)	
Δmgh_{t-2}	---	---	---	---	**0.169**	---
					(0.123)	
$ECT1_{t-1}$	**-0.384**	**0.179**	---	**0.062**	**0.099**	**-0.132**
	(0.000)	(0.001)		(0.138)	(0.087)	(0.001)
$ECT2_{t-1}$		**-0.091**	**-0.024**	**0.091**	**-0.047**	**0.042**
		(0.001)	(0.307)	(0.000)	(0.129)	(0.030)
Δliw_t	**0.351**	---	---	---	---	**0.221**
	(0.022)					(0.005)
Δbvu_t	----	----	---	**0.401**	---	----
				(0.000)		

Also, a 10% increase in Limbe prices increases Bvumbwe prices marginally by 1%. However, if Bvumbwe prices increased by 10% in the previous month, this would increase current prices by 4%. Lastly, table 8 shows that Mangochi prices are mostly driven by Bvumbwe and Liwonde prices. A 10% increase in Bvumbwe prices in the previous month increases Mangochi prices by 6%, while a 10% increase in Liwonde prices in the previous month decreases Mangochi prices by 4%.

6. Conclusions and policy implications

This paper has systematically examined the behaviour of the dry beans market in Malawi using a linear multivariate systems approach. Specifically, the paper applied Structural Vector Equilibrium Correction Model (SVECM) to analyse long- and short- run dynamics of the market. The study aimed to determine the effect of market liberalisation on market efficiency and integration.

Over the period under investigation, the results indicate that dry beans markets in Malawi are integrated. The results also indicate that for nominal price data, Southern region markets are relatively more integrated than Northern region markets. Within respective market systems, only a handful of price vectors are instantaneously correlated. Proximity and the level of trade between markets seem to influence the strength of relative price correlations. For the Northern region market system, the Chitipa market is instantaneously correlated to Karonga market; and both Chitipa and Karonga markets instantaneously influence Rumphi prices. For the Southern region market system, Liwonde is instantaneously correlated to Ntaja and Limbe markets; Mangochi is instantaneously correlated to Limbe; Luchenza is instantaneously correlated to Ntaja; and Bvumbwe is instantaneously correlated to Luchenza.

In terms of the relationships between central markets and their corresponding peripheral markets, central markets drive prices in peripheral markets. Specifically, the Mzuzu central market (Northern region) drives prices in Mzimba and Karonga markets with a one month period lag. The Mzuzu market increases Mzimba and Karonga prices in real terms. For the Southern region, the Limbe market drives prices in Ntaja, Liwonde and Bvumbwe markets. The Limbe market increases prices of the three markets. However, Limbe market prices are mostly driven by Liwonde and Ntaja prices.

In terms of policy implications, the reduced rank hypothesis test results provide some evidence in support of the premise that market liberalisation enhances market integration. However, for this particular analysis, the evidence is not as strong. This suggests the existence of potential structural weaknesses in commodity marketing systems in Malawi. These weaknesses are preventing market forces from reaching their full potential in governing price formation and signalling commodity movement across the country. This suggests that the gains from liberalising markets are yet to be fully realised. For this specific case, market liberalisation will not maximise gains from trade without the proper development of infrastructure (roads and telecommunication), organisation and education of farmers.

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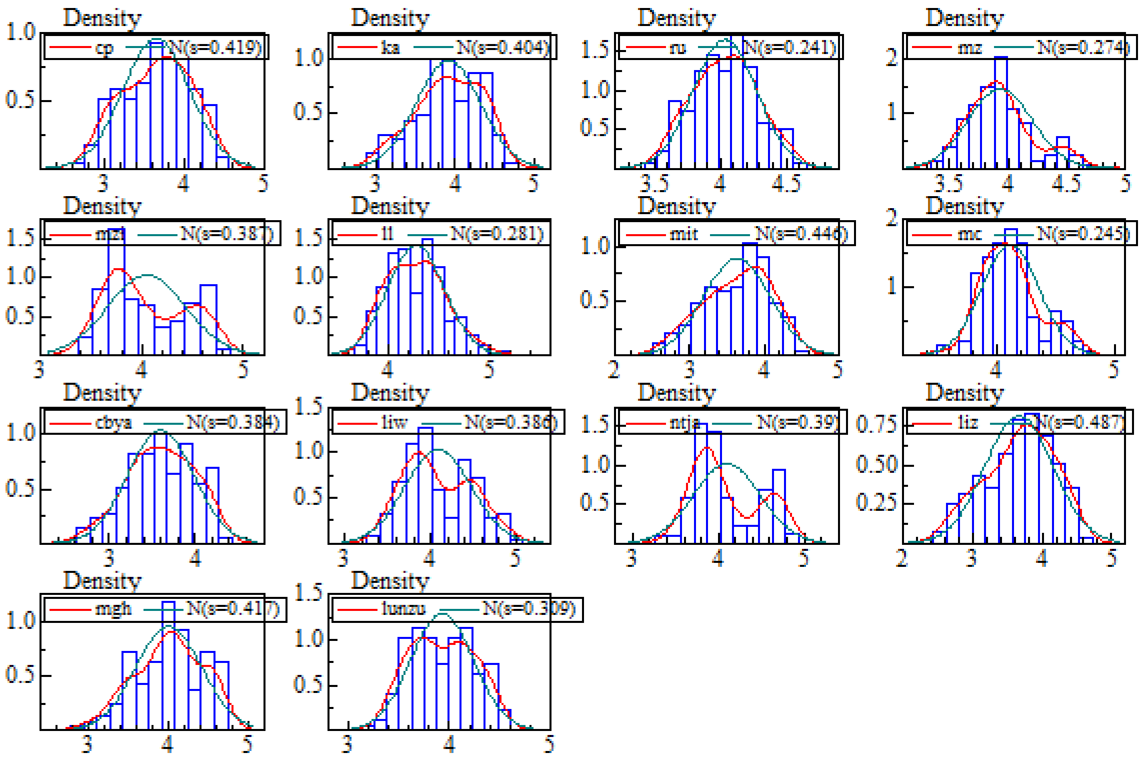
Annex 1.

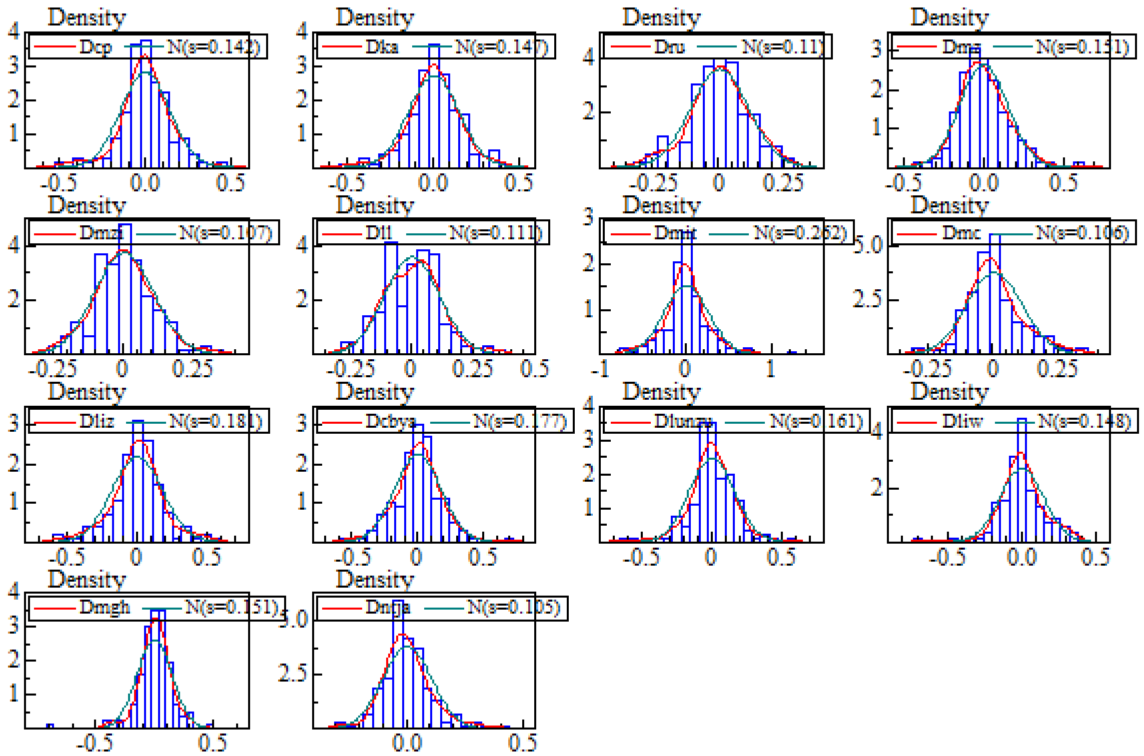
Table 9: Variable Description (Log-levels)

cp_t	ln(Chitipa)
ka_t	ln(Karonga)
ru_t	ln(Rumphi)
mz_t	ln(Mzuzu)
mzi_t	ln(Mzimba)
luz_t	ln(Lunzu)
liw_t	ln(Liwonde)
mgh_t	ln(Mangochi)
$ntja_t$	ln(Ntaja)
le_t	ln(Limbe)
bvu_t	ln(Bvumbwe)
$luch_t$	ln(Luchenza)

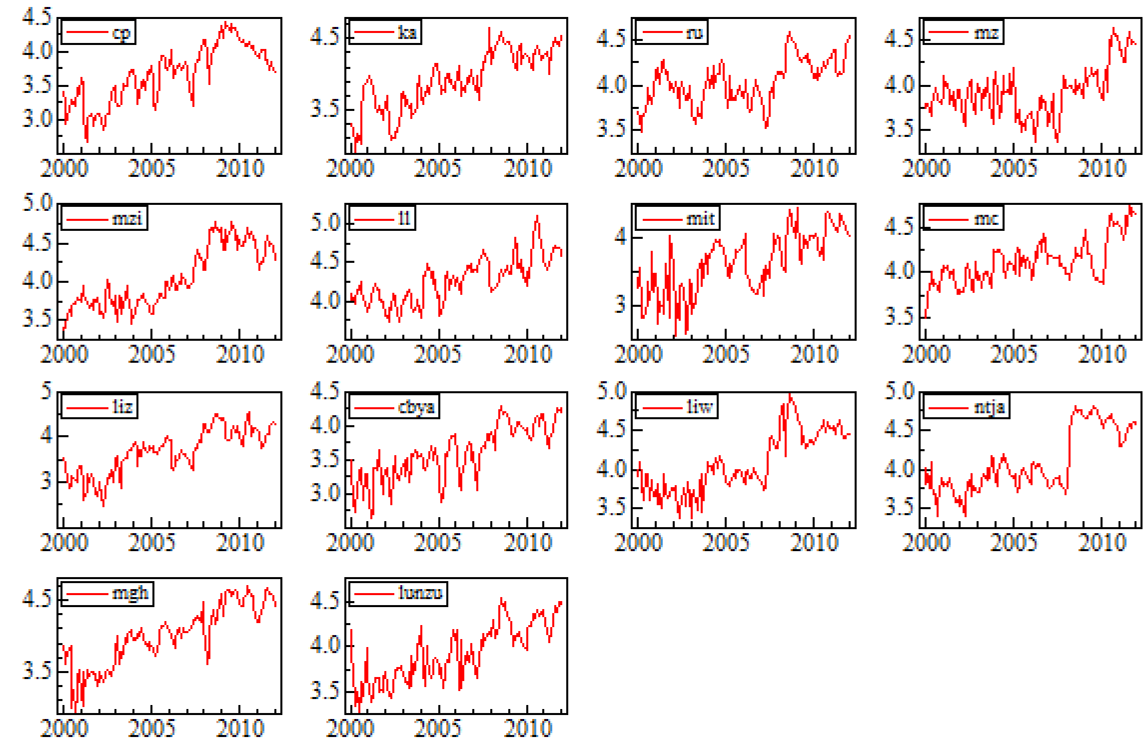
First Differences	
Dcp_t	$\Delta \log cp_t$
Dka_t	$\Delta \log ka_t$
Dru_t	$\Delta \log ru_t$
Dmz_t	$\Delta \log mz_t$
$Dmzi_t$	$\Delta \log mzi_t$
$Dluz_t$	$\Delta \log luz_t$
$Dliw_t$	$\Delta \log liw_t$
$Dmgh_t$	$\Delta \log mgh_t$
$Dntja_t$	$\Delta \log ntja_t$
Dle_t	$\Delta \log le_t$
$Dbvu_t$	$\Delta \log bvu_t$
$Dluch_t$	$\Delta \log luch_t$

Appendix 2: Empirical densities of price vectors for log-levels and first differences





Annex 3: Time series graphs in log-levels and first differences



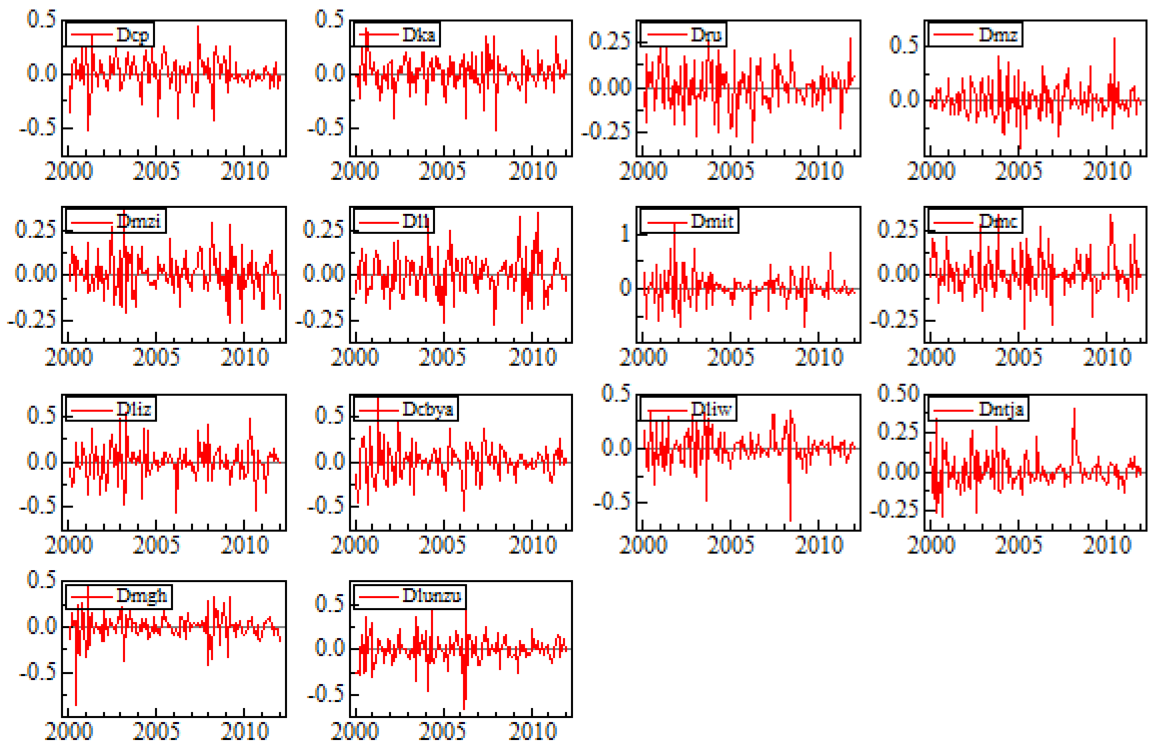
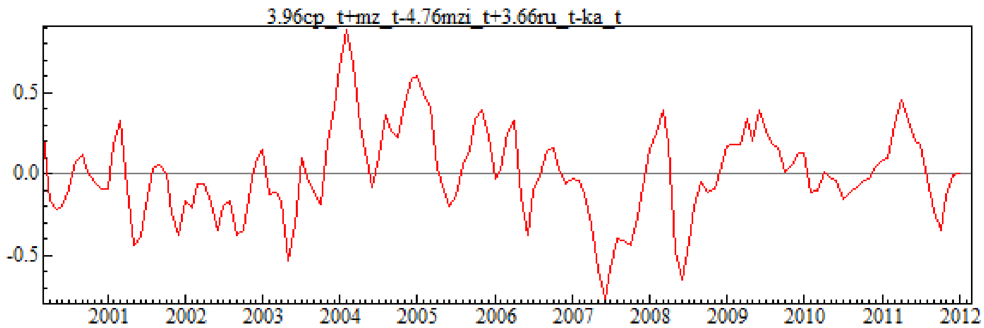


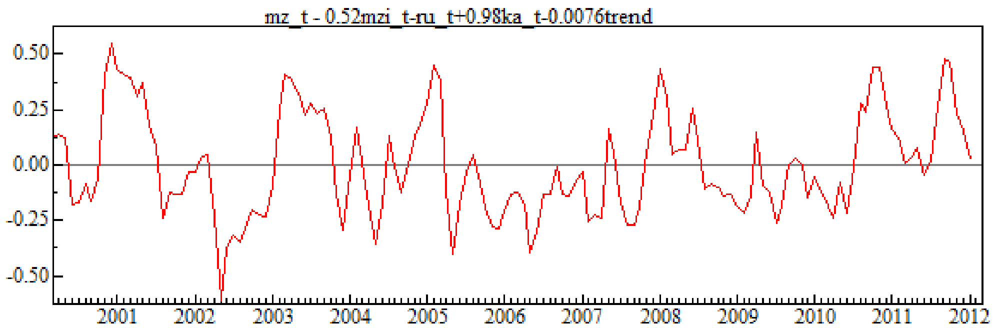
Table 10: Unit root test results

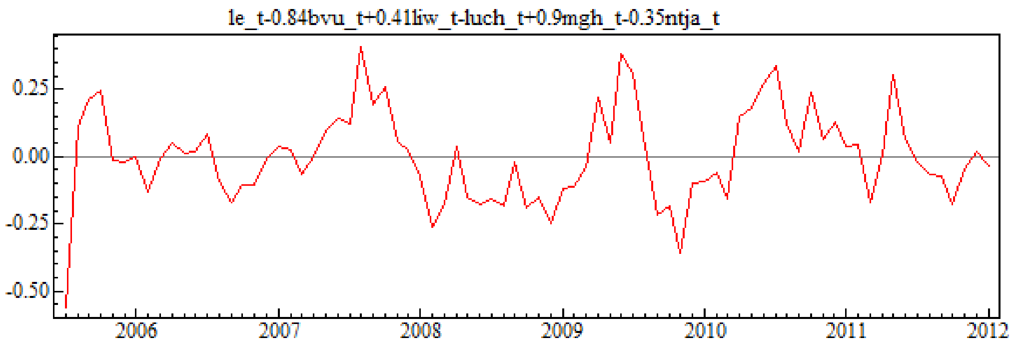
Logs of levels			First differences	
Market	**optimal lag**	**ADF-test statistic**	**optimal lag**	**ADF-test statistic**
Chitipa	3	-2.824	2	-3.993
Karonga	7	-3.121	3	-7.598
Rumphi	11	-2.875	8	-6.274
Mzuzu	4	-2.011	3	-9.707
Mzimba	6	-1.932	5	-7.548
Liwonde	1	-1.704	0	-6.885
Mangochi	12	-0.8679	11	-3.913
Ntaja	7	-2.537	6	-4.488
Limbe	11	-3.193	10	-3.860
Bvumbwe	1	-3.433	0	-5.543
Luchenza	5	-1.662	4	-4.872

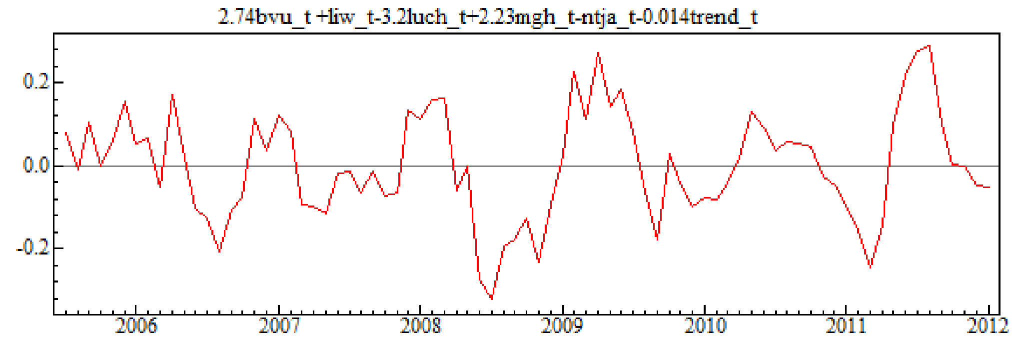
The critical ADF (constant + trend) statistic at 5 percent level of significance for log-levels and first differences is -3.47 and -4.09 at 1% level.

Annex 4: Time series graphs of cointegrating vectors









Annex 5: Final restricted lower triangular matrix

Matrix 1: Final structure of the restricted B^r matric

$$\begin{matrix} Dcp \\ Dmz \\ Dmzi \\ Dka \\ Dru \end{matrix} \begin{bmatrix} 1 & & & & \\ 0 & 1 & & & \\ 0 & 0 & 1 & & \\ b_{41} & 0 & 0 & 1 & \\ b_{51} & 0 & 0 & b_{54} & 1 \end{bmatrix}$$

Matrix 2: Final structure of the restricted B^r matric

$$\begin{matrix} Dliw \\ DNtja \\ Dle \\ Dbvu \\ Dluch \\ Dmgh \end{matrix} \begin{bmatrix} 1 & & & & & \\ b_{21} & 1 & & & & \\ b_{31} & 0 & 1 & & & \\ 0 & 0 & 0 & 1 & & \\ 0 & 0 & 0 & b_{54} & 1 & \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$