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Mezgebo, Taddese

Mekelle University

14 November 2009

Online at <https://mpra.ub.uni-muenchen.de/18663/>

MPRA Paper No. 18663, posted 16 Nov 2009 15:18 UTC

***A multivariate approach for
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*Taddese Mezgebo
Economics Department
Collage of business and Economics
Mekelle University*

Two surplus markets of Bale Robe and Shashimiene and one deficit market of Jimma are observed to fix long run price. However the system is observed to have better capacity to process demand side than supply side shocks. Therefore for efficient stabilization the focus should be in Jimma. For equity and political feasibility it would be preferable if poor deficit centers are provided with subsidized supply of grain, too. Though distance did not seem to be an important factor for border of one price but only for strength of cointegration, the methodology used by early papers is observed to work.

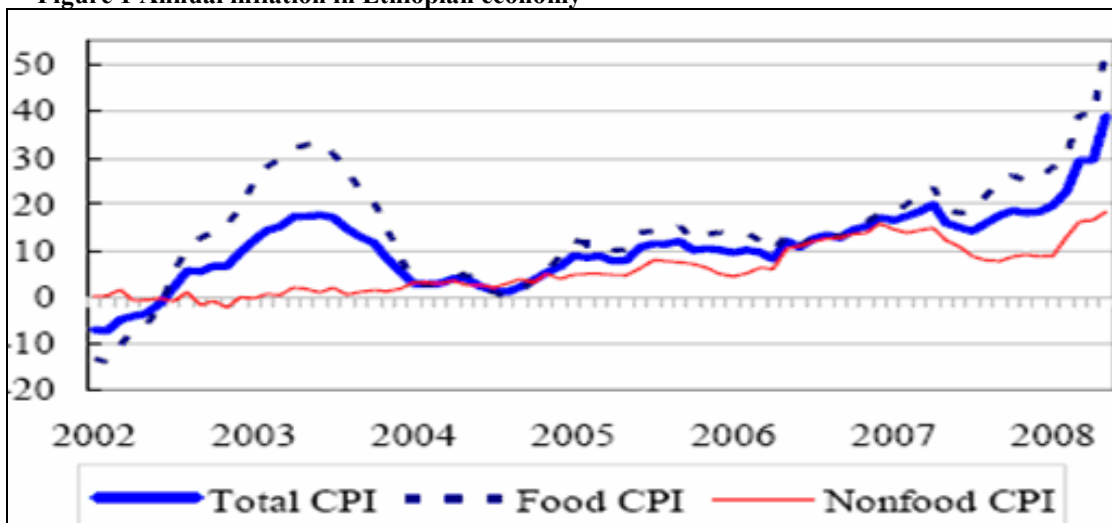
Taddese Mezgebo, tame_new@yahoo.com, November 14, 2009

A multivariate approach for identification of optimal locations with in Ethiopia's wheat market to tackle soaring inflation on food price

I. Introduction

After years of low and some times negative inflation Ethiopia is experiencing soaring food and general inflation. In 2000 the level of inflation in consumer price index was 6.2% and in just next two years of 2001 and 2002 it turned in to -5.2% and -7.2%, respectively (WB 2008/9). And in general for most of the years in period of 1991 to 2002 the country was experiencing either very low inflation or in some years even deflation. However in recent years and mainly starting from 2006 the country is experiencing double digit inflation reaching as high as 40% in 2008 (see figure 1 below).

Figure 1 Annual inflation in Ethiopian economy



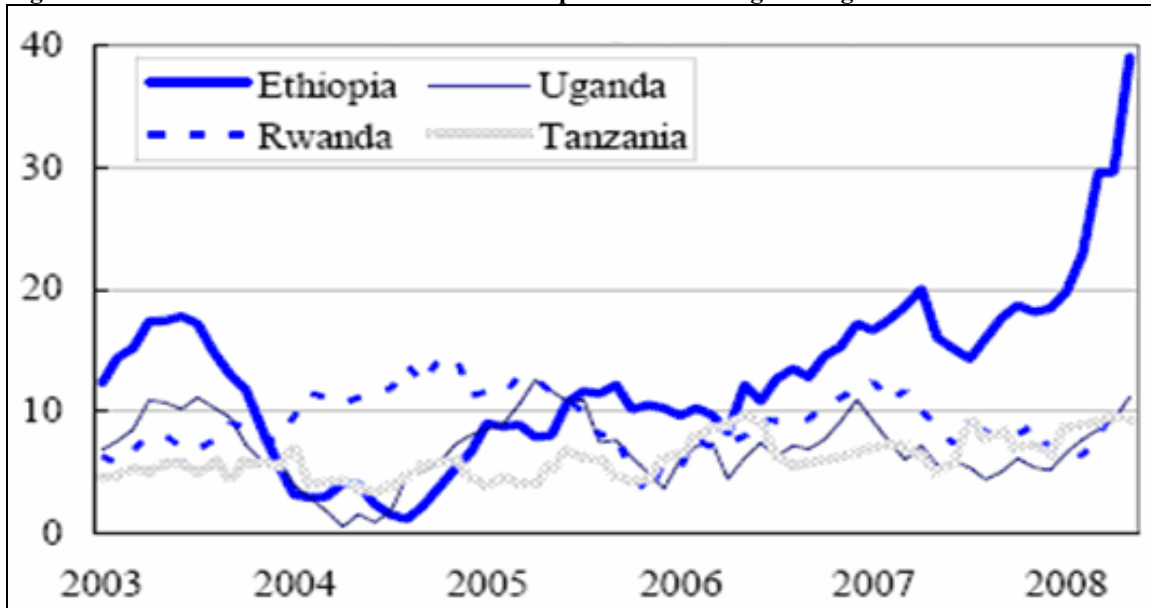
Source IIMF(2008) IMF Country Report No. 08/259

As can be seen in figure 1 above this is mainly related to ever soaring food prices as the over all price index is just a shadow of the food price index. Moreover study by Loening et al (2009) did found that over all inflation is highly related to inflation in cereal prices. What is puzzling is that the unprecedented level of inflation on food price is observed when all data collected by both government and international agencies are showing the country is having record level agricultural production.

Additionally figure 2, below, clearly shows that the level of inflation observed in the country is much higher than the inflation observed in neighboring countries. This fact implies that Ethiopia's last few years unprecedented inflation is less associated with regional economic dynamics than domestic economic dynamics. Study by Loening et al (2009) did found that the main causes of inflation in the long run are the foreign exchange rate and the international price of food and other goods. In short run supply shocks and inflation inertia followed by money supply growth are strong determinants of inflation. It is hard to swallow the above result when most of the inflation is observed in

staple grains which are none tradable for Ethiopia¹ and when oil price is increasingly subsidized by state with every increase in international price of oil. Moreover a study by Ulimwengu et al (2009) did show that domestic maize price are not cointegrated with international maize price, which support the view that Ethiopian food inflation, which is the major cause of the over all inflation, is not caused by Global or regional factors but by domestic factors.

Figure 2 Relative annual inflation between Ethiopia and three neighboring countries



Source 2 IMF(2008) IMF Country Report No. 08/259

So even though understanding the source of the problem can improve the effectiveness of any intervention, consciousness does not seem to exist between stakeholders about the real domestic source of the problem and effective solution to the problem (see IMF 2008). One of the possible solutions forwarded by government is to intervene in grain markets through international purchase and distribution of white wheat in to the domestic economy.

However such intervention if needed to be effective and efficient needs to be targeted in optimal locations where effective stabilizing intervention can be done with least possible cost. In this paper optimal locations which can be used for stabilization of white wheat price are identified by using a vector error correction model (VECM) developed by Johansen (1988 and 1991) with search criteria for one common trend introduced by Gonzalez – Rivera and Helfand (2001). Some modifications are introduced in to Gonzalez – Rivera and Helfand (2001) search methodology to make it more robust to unnecessary assumptions. Moreover the short run dynamics of the market are articulated by analyzing the adjustment parameters estimated in VECM and persistence profile for system level shock developed by Pesaran and Shin (1996). Additionally the markets which are having major impact on the long run common trend, which in turn is keeping

¹ The same study by Loening et al (2009) did state that food imports are less than 5% of agricultural GDP, for example.

the prices under rule of one price, is estimated by following Gonzalo and Granger (1995) common trend estimation methodology.

The data used for this paper is collected by European Union under price information system project and is obtained from Ethiopian Grain Trade Enterprise (EGTE). The data is extended from 1980 to 2003. Unfortunately, most of the data for pre 1996 was compiled from different records and there are many none random missing values. However for 8 wholesale markets, more or less, complete monthly data is found from 1996 to 2003. There are few random missing values in some months but they are extrapolated from the data. To extrapolate the missing value first the price is regressed on monthly dummy and year and the predicted value is used as initial value. Then given monthly nature of the data auto regressive model with 15 lags or AR(15) is fitted and the predict value is replaced for the originally missing value. And recursive estimation, prediction and replacement are done until the difference between used value and new predicted value becomes very close to zero. The basic idea is to extrapolate the needed information from the data itself by considering the information on the lagged values of the level price. Following this introductory part the methodology used in this paper will be fully but concisely explained next.

II. Econometric methodology

2.1. Introduction to econometric methodology

The main focus of the paper is to determine the long run and short run relationship that exists between wheat market prices based on vector error correction model (VECM). The level of integration of wheat markets located in different parts of the country under rule of one price is very informative in guiding stabilization efforts in to optimal locations. Such optimal location selection can improve the effectiveness of any stabilization policy.

If the markets in different location are highly integrated few or even one market can be used to stabilize the whole country. But if the markets are not integrated under rule of one price optimal stabilization may need simultaneous intervention in different part of the country. Moreover if there are many markets under rule of one price the market/s place where optimal intervention can be targeted can be identified depending on the statistical significance of the adjustment parameters, the speed of adjustment of each market to equilibrium following system wide shock and the relative importance of each market in determination of the single common trend, which is keeping the prices under rule of one price.

The prices of the same grain in different markets are expected to have an equilibrium and strong long run relationship, which can be modeled by VECM. The conventional approach to VECM is first to determine the appropriate lag by one of the few information criterions. And for given lag to use trace statistics or maximum Eigen value to determine the number of cointegration relationships found in the market by estimating the vector error correction model in reduced rank regression form (Johansen 1988 and 1991). And assuming that there are theoretical bases which can identify the cointegration equations, it

will be fruit full two step process.

Unfortunately for grain prices theory tale us that if there is free flow of information and goods all market prices should be cointegrated under one common trend, unless transaction costs are not stationary. If we get $n-1$ cointegration relations there is no identification problem as all markets are pair wise cointegrated and all are following a single common trend² (Gonzalez – Rivera and Helfand, 2001). But if the number of cointegration relationships are less than $n-1$, there will be identification problem in which neither theory nor empirical evidence will be help full. Empirical evidence mainly the cointegrating parameters identify the space spanned by the cointegrating vectors not the true cointegrating vectors. Normally theory is used to fix the restrictions needed to identify the cointegration equations. But for grain prices theory is not that much helpful in identifying the cointegrating eqautions. So the solution is to turn the process up side down as is done by Gonzalez – Rivera and Helfand (2001) on their study of Brazil rice markets and Rashid (2004) in his study of Uganda maize markets.

This non conventional approach follows the process of searching $n-1$ cointegrating prices through routine search starting from $m < n$ well connected markets to ward $n-1$ markets, which are following 1 common trend. In the Gonzalez – Rivera and Helfand (2001) paper the search was started from 10 markets which are assumed and found to be strongly cointegrated at two lags. Test for normality, ARCH effect, serial correlation and other tests however were done only for the final model of 15 markets. In Rashid (2004) paper the search is started from two markets and at each stage normality is tested but not serial correlation.

In the first paper estimate of trade flow in addition to unit root test is used to determine the first 10 markets. Other markets are added sequentially given they are following 1 common trend. And it was observed that distance is an important factor on explaining, if a given market is to be part of the one common trend or not. Moreover if the market is close to the cointegrated markets and mainly to the capital city there is high probability that it will show strong cointegration under one common trend with the cointegrated markets. In Rashid's (2004) adaptation of the methodology the search is started from capital city and another major regional market center (Jinja). And based on their distance from the Kampala (the capital city of Uganda) other markets are added sequentially. In each sequence normality test is done and lags are added when ever necessary to achieve normality of the error terms. But test for serial correlation was not done at each stage. Unfortunately, the unit root and rank test are basically dependent on the assumption of independently distributed error terms for all sample sizes and normally, identically and independently distributed error terms for small sample sizes (Johansen 1988, 1991). So it is more logical if each search is followed by necessary testes to make sure that the error terms are white noise. In this paper test for normality, serial correlation and ARCH effect are done at each stage.

If the vector auto regressive model (VARM) of two or more markets has a shortest lag, it

² Still out of p_n^n cointegration vectors only $n-1$ are relevant and others are redundant.

could possibly imply the markets under this relationship are highly cointegrated to one another; which in turn could imply strong codependence compared to another group of markets. And this is in line with early models of market integration based on Ravallion (1986) bivariate auto regressive (VAR) model, which infers markets are integrated in short run if the coefficients of lagged prices are statistically equal to zero. And the shorter is the lag the more integrated the price are (Sadoulet and Janvry 1995).

But the Ravallion bivariate vector auto regressive model (VAR) has three methodological problems. First it does not consider the entire market as one structure, but it only considers two markets in isolation and this can introduce specification bias (Gonzalez – Rivera and Helfand 2001). Second it will have indignity problem since each price can granger cause the other (Sadoulet and Janvry, 1995). But the third major problem is since it uses first difference of prices it does not consider the long run relationship possibly existing between prices discovered in spatially disconnected markets. So the right way to model cointegration of prices is to use VECM which accounts for all the above shortcomings of the Ravallion model.

But there is a problem to this procedure when applied to cointegrated system. First in cointegration relationships we have two short term groups of parameters. These are the group of lags and the group of adjustment parameters. In bivariate VAR using first difference of prices markets with shorter lags are very closely related markets. But in VECM such conclusion is not possible since there are two groups of short run parameters. The adjustment parameters will measure the response of a market to shock initiated in given cointegrating equation. But the shocks will persist through the long memory component as reflected by the coefficients on lagged first difference. So the overall adjustment to system wide shock has to be analyzed. To do so persistence profile developed by Pesaran and Shin (1996) is used.

Additionally the VECM will introduce its own identification problems. One is related to the fact that if two markets say X and Y have strong relationship at short lag with low level of persistence, it does not necessary mean any market combination with strong long run relationship need to be based on them. It is possible that A and B markets can have zero or weak relationship pair wise compared to X and Y, but if C is added to A and B, the strength of A, B and C can be much stronger than X, Y and any other market. This is so because low dimension estimation of high dimension relationships will introduce omitted variable bias (Gonzalez – Rivera and Helfand 2001). However in both Gonzalez – Rivera and Helfand (2001) and Rashid (2004), it is assumed that any strong long run relationship has to be based on X and Y. Means implicitly they are assuming strength reversal is not possible.

But most importantly even though in Gonzalez – Rivera and Helfand (2001) the search was not sensitive to the order of markets, it was not found to be true in this paper. If tests are done at each stage normality test result is found to be very sensitive to slight change of order. This implies we have to search from large permutation not small combination of markets to identify markets which are operating under rule of one price.

To account for such possibility, in this paper first all possible permutation of markets are tested and the over all market dynamics is mapped by searching for one common trend using trace statistics developed by Johansen (1988, 1991). And if distance have to be the determining factor in order of inclusion, if the capital city need to be the center of market dynamics and if the reversal of strength can be observed or not is left to be observed from the data and it is not assumed in to the model.

The advantage of this procedure is related to the fact that it does not impose unproven assumptions in to the model. The disadvantage is that the search will be very tedious process which needs large permutation³ of markets. For number of prices equal to n and maximum number lags (L_i) considered in i permutation of markets⁴ the total number permutation of markets to be tested is equal to

$$(p_2^n \times L_2) + (p_3^n \times L_3) + (p_4^n \times L_4) + \dots + (p_n^n \times L_n)$$

In this study given small sample size of 96 observations of monthly price dated from 1996 to 2003, it is pushed for strict normality and lack of serial correlation. So unless the null of normally and independently distributed error terms and vectors can not be rejected up to 10% level of significance at best and 5% at worst, the hypothesis of correct market order is rejected. If the market permutation is having independently and normally distributed error vector, ARCH test is also done to measure the level of time dependent heteroskedasticity. For better understanding of this research result the methodologies used in this paper are briefly explained below.

2.2. The ADF unit root test and VECM for cointegration

The first step in any cointegration analysis is the determination of number of unit roots found in the data. For the purpose of unit root analysis Augmented Dickey and Fuller test developed by Dickey and Fuller (1979) is used. The ADF test uses the following OLS regression

$$\Delta P_t = \alpha + \beta t + \zeta_1 \Delta P_{t-1} + \zeta_2 \Delta P_{t-2} + \dots + \zeta_{m-1} \Delta P_{t-m+1} - \lambda P_{t-1} + \varepsilon_t \dots \dots \dots 1$$

The ADF testes for unit root is a test for statistical significance of the lagged price coefficient (λ). Test for on unit root the level prices are used in place of P_t in equation 1. And for possible second root the first difference of level price (ΔP_t) is used in place of P_t in equation 1 above.

The test follows the same procedure used for normal or student-t kind of test but the calculated values are evaluated against critical value simulated from DF distribution. The problem is that based on the assumption about the value of drift (α) and trend (β) there are three different critical values that can be used. The million Dollar question is which

³ Permutations than combinations have to be used since normality is order sensitive.

⁴ For the 8 wheat prices traded in different markets it took around 30 hours of computer time on computer with 1.79 GHZ processor.

critical value to use with out knowing the value of drift and trend. To solve this circular problem general to specific search procedure as advised by Hamilton (1994) and Peterson (2000) based on F-kind of testes developed by Dickey and Fuller (1979) is used. So if the data have some visible trend but we are not sure if it is caused by random trend around drift or deterministic trend with stationery data we can check which one is right by using Φ_3 test. This test checks for joint significance of the trend coefficient (β) and unit root coefficient(λ). If the null of $\beta = \lambda = 0$ is accepted the data is following unit root around drift. If the null is rejected it means the data is stationary around deterministic trend⁵. The Φ_3 test though is F kind of test it will follow different distribution as tabulated by Dickey and Fuller (1979).

However if the data did not has visible trend but has none zero mean we have to start from Φ_1 . The Φ_1 test will check for joint significance of drift (α) and the unit root term (λ), with null that both are equal to zero. If the null is accepted the data is following unit root around zero means the none zero mean is caused by persistence of shocks. But if it is rejected assuming the data have none zero mean but did not have visible trend the data is stationary around drift.

Once the more general Φ_1 and Φ_3 testes are used specific t-version ADF test can be used based on the conclusion of either Φ_1 or Φ_3 , which every is appropriate. The use of t-version ADF test will improve the power of the test and is, therefore, needed. Once the number of unit roots is identified for each price the next step is to use Johansen (1998, 1991, 1992) VECM among prices which are having one unit root to see if they are cointegrated.

The log price (P) of a commodity in given market (i) can be presented by variable P_i . And all n log prices in n locations can be presented by n dimensional vector \mathbf{P} .

$$\mathbf{P}'_t = [P_1 \quad P_2 \quad . \quad . \quad . \quad P_n] \dots\dots\dots 2$$

If the prices are cointegrated they will have the following error correction representation based on Granger representation theorem (Engle and Granger 1987).

$$\Delta \mathbf{P}'_t = \delta^* + \pi^* \mathbf{t} + \zeta_1 \Delta \mathbf{P}'_{t-1} + \zeta_2 \Delta \mathbf{P}'_{t-2} + \dots + \zeta_{p-1} \Delta \mathbf{P}'_{t-p+1} - \mathbf{B} \mathbf{A}' \mathbf{P}'_{t-1} + \boldsymbol{\varepsilon}'_t \dots\dots\dots 3$$

Vector $\boldsymbol{\varepsilon}'_t$ is white noise n dimension vector with variance covariance matrix $\boldsymbol{\Omega}$. In which $E(\boldsymbol{\varepsilon}'_t \boldsymbol{\varepsilon}'_\tau) = 0$ for $t \neq \tau$ means the error vectors are independent and $E(\boldsymbol{\varepsilon}'_t \boldsymbol{\varepsilon}'_t) = \boldsymbol{\Omega}$ for $t = \tau$ means there error vector has constant variance matrix. The $(n \times h)$ matrix of \mathbf{A} is the cointegrating vector defining the long run relationship between $h+1$ prices. And

⁵ This conclusion is based on the assumption that the data is visibly tended. The logical argument in detail can be found in Peterson (2000) or in working paper version of this paper in Taddese (2009).

the $(n \times h)$ matrix of \mathbf{B} represent the adjustment parameters. The adjustment parameters show the speed of adjustment of prices for any random deviation from the long run equilibrium between the $h+1$ prices.

The number of cointegration equation is identified by using trace statistics developed by Johansen (1998, 1991). If LL_A is the log likelihood of equation 3 assuming that all prices are stationery and LL_H is the log likelihood assuming n prices are cointegrated with h cointegration relationships, the λ_{trace} or trace statistics given in equation 4, below, will follow DF family distribution developed by Johansen (1998, 1991) with $n-h$ degree of freedom or number of common trends under alternative hypothesis.

$$\lambda_{\text{trace}} = 2(LL_A - LL_H) = -T \log \prod_{i=h+1}^n (1 - \lambda_i) \dots\dots\dots 4$$

The eigen values λ_i are related to the smallest $n-h$ eigen values in the canonical matrix of the prices. However there are 5 different version of the VECM in equation 3. So the following statistics can be used for model selection.

$$\lambda = 2(LL_{UR} - LL_R) \dots\dots\dots 5$$

Where LL_{UR} is unrestricted model's log likelihood and LL_R is the restricted model's log likelihood. This will follow Chi2 distribution with $n-h$ degree of freedom. As given in equation 3 the cointegration equations are estimated based on the assumption that the error vector $(\boldsymbol{\varepsilon}_t)$ is white noise with variance covariance matrix equal to $\boldsymbol{\Omega}$. In which $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_\tau') = 0$ for $t \neq \tau$ means the error vectors are independent and $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t') = \boldsymbol{\Omega}$ for $t = \tau$ means there error vector have constant variance. Moreover it is assumed that the error vector follows multivariate normal distribution in order to develop the Brownian distribution based distribution for rank test (See Johansen 1988, 1991 and Hamilton 1994). But as developed in Johansen (1988, 1991) and clearly explained in Hamilton (1994) the most critical assumption is the independence of the error vectors. The rank test can be applied asymptotically to none normal distributions with heteroskedastic variance. In this paper even though the time period is 8 years which is not very small for cointegration analysis the use of monthly data did restrict number of observations to just 96. So normality, independence and constancy of the variance are demanded in each VECM estimated.

For normality Jarque and Bera (1980, 1981) or J-B test is used. A Monte Carlo simulation by Demiroglu (2000) did show that JB test is equally applicable to both integrated series and cointegrated vectors as it's for stationary series. For serial correlation LM test developed by Breusch (1978) and Godfrey (1978) is used. And a Monte Carlo simulation by Brüggermann et al (2006) did show that it is equally applicable in cointegrated or none cointegrated vectors.

The Johansen VECM and related rank testes are asymptotically applicable for both homoskedastic and heteroskedastic errors (Johansen 1988 and 1991, Hamilton 1994, Cavaliere et al 2009 and Lee and Tse 1996). However in small and moderately small samples heteroskedasticity is observed to reduce the power of rank testes marginally (Lee and Tse 1996, Cavaliere et al 2009). To test for auto regressive conditional heteroskedasticity (ARCH) effect discovered by Engle (1982) or its extension to generalized auto regressive conditional heteroskedasticity (GARCH) by Bollerslev (1986) we can use the residuals from the vector error correction model. The test for ARCH(q) or GARCH(p, q) = ARCH(p + q) will follow conventional normal, F, student-t and Chi-square distributions under the null of white noise errors. Once the cointegration equations are estimated the next step is to estimate the main determinants of the common trend. This is done by following Gonzalo and Granger (1995) methodology, explained below.

2.3. Estimation of common trend

If n markets are under rule of one price there will be $n - 1 = h$ cointegration relations and 1 common trend. The estimation of this single common trend will be useful in order to understand the importance of a given market in determination of the common trend. A market which is highly cointegrated with other markets, which is also having significant impact on the common trend, which is having short persistence of shocks and which is more or less weakly exogenous will be the market where efficient stabilization can be done in cost effective manure.

The estimation of the long run trend will be done using Gonzalo and Granger (1995) linear decomposition of price vector in to permanent and temporary component as

$$\mathbf{P}_t = \mathbf{A}_1 f_t + \tilde{\mathbf{P}}_t \dots\dots\dots 6$$

Where \mathbf{P}_t , \mathbf{A}_1 and $\tilde{\mathbf{P}}_t$ are n dimension vectors and f_t is a scalar of common trend related to single common trend under the model used here. So the prices are function of permanent component (f_t) loaded by loading matrix (\mathbf{A}_1) plus temporary component ($\tilde{\mathbf{P}}_t$). The basic assumption imposed by Gonzalo and Granger (1995) and used to estimate the common trend is that f is linear on observed prices and the temporary component does not have permanent impact on prices. Formally the first assumption imply

$$f_t = \mathbf{a}'_{\perp} \mathbf{P}_t \dots\dots\dots 7$$

The vector of coefficient in equation 7 or \mathbf{a}'_{\perp} can be estimated by using the null space of the cointegrated vectors as shown by Gonzalo and Granger (1995)⁶. The common trend

⁶ One important point to mention is that in this paper the null space found in canonical vector related to the smallest Eigen vector is estimated by imposing $\hat{\mathbf{H}}' \hat{\mathbf{H}} = \mathbf{I}$ than $\mathbf{H}' \sum_{w_t w_t} \mathbf{H} = \mathbf{I}$ as demanded. So

will be given by equation 7. The statistical significance and the numeric significance of \mathbf{a}'_{\perp} will be use full in providing information about the relative importance of a given market in the general price formation. And as proved by Gonzalo and Granger (1995) a conventional Wald test can be applied given the vector error correction model is correctly specified, identified and estimated by Johansen (1988 and 1991) VECM frame work. Or simply we can use the following log likelihood test

$$L = -T \sum_{i=r+1}^p \ln \left(\frac{1 - \lambda_{p-i}}{1 - \lambda_p} \right) \dots\dots\dots 8$$

Where λ_p is the smallest Eigen value in the unrestricted model and λ_{p-i} is the smallest Eigen value when the impact of i markets is constrained to be zero. This has Chi2 distribution with $p - m$ degree of freedom. Where p and m are number of Eigen values in unrestricted and restricted models, respectively.

As rightly stated by Pesaran and Shin (1996) researches which simply focus in long run may not be complete and may not be able to generate very useful recommendation for policy makers, unless their research and prescription is complemented by short run analysis. So a summarized measure of short run dynamics is developed by Pesaran and Shin (1996) and is explained below.

2.4. Estimation of persistence profile

In bivariate error correction model the size and sign of adjustment parameters and the statistical significance of the adjustment parameters will be used to analyze the short run dynamics of the market. If adjustment parameter is -0.33, it means it will take 3 (= 1/0.33) periods for the market to correct the shock initiated in its long run relationship with other markets. Moreover if the markets have shorter lags it means the markets have short memory of past shocks or to follow Ravallion (1988) thinking they have strongly cointegration in short run. To summarize the impact of both short run groups of parameters impulse response functions are widely used in literature. However impulse response functions are found to be less effective, if shocks are correlated. And the orthogonaization method used to solve the problem is found to be inconclusive, since it is order sensitive (Pesaran and Shin 1996).

Following Pesaran and Shin (1996) persistence profiles are used which are order insensitive to measure the persistence of system wide shock injected in to the cointegration vector equal to $\mathbf{A}'\mathbf{\Omega}\mathbf{A}$. Where \mathbf{A} is the cointegrating vector and $\mathbf{\Omega}$ is the

following Hamilton (1994) the coefficients estimated by imposing $\hat{\mathbf{H}}' \hat{\mathbf{H}} = \mathbf{I}$ are converted in to coefficients that can be estimated by imposing $\mathbf{H}' \sum_{w_t w_t} \mathbf{H} = \mathbf{I}$ using the formula $\mathbf{h}_i = \hat{\mathbf{h}}_i \div \sqrt{\hat{\mathbf{h}}_i' \sum_{w_t w_t} \hat{\mathbf{h}}_i}$. For clear understanding of the terms and the idea see Hamilton (1994) or the working paper version of the paper in Taddese (2009)

variance covariance matrix. The advantage of persistence profile is that it is order insensitive for given identification assumption imposed in error correction model. However still it is sensitive to the identification assumption imposed. Following shock equal to $\mathbf{A}'\mathbf{\Omega}\mathbf{A}$ at period zero the change in variance of forecast error in period n is given by $\mathbf{A}'\mathbf{A}_n\mathbf{\Omega}\mathbf{A}_n'\mathbf{A}$ where \mathbf{A}_n is equal to

$$\mathbf{A}_n = \mathbf{\Phi}_1\mathbf{A}_{n-1} + \mathbf{\Phi}_2\mathbf{A}_{n-2} + \mathbf{\Phi}_3\mathbf{A}_{n-3} + \dots + \mathbf{\Phi}_p\mathbf{A}_{n-p} \dots\dots\dots 9$$

The coefficients under $\mathbf{\Phi}_i$ are recursively derived from equation 3 by using the following formulas given in equation 10, below.

$$\begin{aligned} \mathbf{\Phi}_1 &= \mathbf{I}_n + \zeta_1 \quad \text{if } p > 1 \\ \mathbf{\Phi}_1 &= \mathbf{I}_{p+1} + \zeta_0 = -\mathbf{I}_n - \mathbf{BA} \quad \text{if } p = 1 \\ \mathbf{\Phi}_i &= \zeta_i - \zeta_{i-1} \quad \text{if } i = 2, 3, 4, \dots, p-1 \dots\dots\dots 10 \\ \mathbf{\Phi}_p &= -\mathbf{BA} - \zeta_{p-1} \end{aligned}$$

At limit given \mathbf{A} is cointegrating vector $\mathbf{A}'\mathbf{A}_n\mathbf{\Omega}\mathbf{A}_n'\mathbf{A}$ will approach to zero. So in persistence profile the adjustment process following shock equal to $\mathbf{A}'\mathbf{\Omega}\mathbf{A}$ can be analyzed by considering the dynamics of relative persistence given by

$$\mathbf{h}(n) = \mathbf{A}'\mathbf{A}_n\mathbf{\Omega}\mathbf{A}_n'\mathbf{A} \times \mathbf{Diag}\left(\left(\mathbf{A}'\mathbf{\Omega}\mathbf{A}\right)^{-1}\right) \dots\dots\dots 11$$

The value of $\mathbf{h}(n)$ will range from 1 when $n = 0$ to 0 when $n = \infty$. The value at given period of n or $\mathbf{h}(n)$ will measure fraction of the initial shock which is persisting at that period. For example if $\mathbf{h}(2) = 0.3$, it means 30% of the shock is not corrected at second period or similarly 80% of the disequilibrium is corrected at second period.

In this paper weighted mean and first month persistence are used. Weighted mean use the simple weighted average of the time of the shock the weight being the level of persistence in each period. Moreover given most the shock is observed to evaporate in first month first month than median persistence advocated by Gonz'alez-Rivera and Helfand (2001) is used. Moreover the time of persistence or half of it as used by Gonz'alez-Rivera and Helfand (2001) could be useful but there is need to show that which values are statistically equal to zero. Pesaran and Shin (1996) did show that the statistical significance of persistence can be analyzed by using conventional distributions but the author can't find any value added that can be generated by using such cumbersome test. So it is dropped in this analysis.

III. Discussion and analysis

3.1. Introduction to Discussion and analysis

Before the data can be analyzed there is need for clear understanding about the importance of appropriate lag selection mainly for VECM but also for ADF test. The VECM is estimated and tested under the assumption that appropriate lag that can be used in the model is known in advance. This is not the case in empirical application. But what is puzzling is that not only any information criterions that can be used for lag selection is not found to be consistently superior for all data generating process⁷ but also VECM model is very sensitive to both over identification and under identification problem (Maringer 2004). Study by Ho and Sørensen (1996), for example, indicated that when longer lags are used inappropriately, Johansen's rank test have tendency to over estimate the number of cointegration equations found in the model. The problem is that the four information criterions used in the study that are Hannan and Quinn information criterion (HQIC), Final prediction error (FPE), Schwartz's Bayesian information criterion (SBIC) and Akaike's information criterion (AIC) are observed to give very conflicting result. Only in rare cases do the four information criterions pick the same lag. And theoretically with out knowing the data generating process of the population it is hard to select any of the criterions. To make things worst the real data generating process is not known in advance. So the criterions are taken not as perfect predictors but as possible lag selectors. Means the maximum and minimum lag used in VECM will be related to the maximum and minimum lags selected by any of the information criterions. And the specific lag for the model will be selected based on the white noisiness of the error vector.

The second problem is related to the fact that the information criterions are found to be very sensitive to the maximum lag allowed in the search process. In theory the maximum lag possible or allowed is assumed to be known in advance. But it is not known in actual empirical analysis⁸. So in this paper maximum lags are selected in interval form from 10 to maximum possible for 2nd and 3rd dimension VECM. But for 4th and 5th dimension VECM the maximum lag allowed are fixed in the range of 5 to maximum possible. For each maximum lag allowed the selected lag is recorded and the used lag in VECM is the modal lag selected. This procedure has two advantages first it will not result on highly under estimated lags since different maximum lags are allowed. But again it will reduce the probability of over fitting and mainly over fitting that can result from the use of inappropriate and higher maximum lag allowed⁹.

The problem in case of ADF test is not that series since over fitting is much preferable to under fitting as is the case for classical regression analysis. Moreover given lower

⁷ See Winker and Maringer (2004), Ho and Sørensen (1996), Khim –Sen (2004), Gutiérrez et al (2007), Chao and Phillips (1999) and others for conflicting result. But more robust analysis is found in study by Gonzalo and Pitarakis (2000) with diverse data generating process.

⁸ For simulation result about the impact of maximum lag allowed you can see Gonzalo and Pitarakis (2000).

⁹ Study by Gonzalo and Pitarakis (2000) did show that when longer lags are allowed in small or moderate sample sizes information criterions have tendency to pick the maximum lag allowed. And this is widely observed in this paper.

dimensional nature of the test and related higher degree of freedom that can be used, normality and heteroskedasticity are not critical condition for the ADF test. But it is important to make sure the error terms are independent since DF distribution is derived from Brownian distribution assuming independent error terms (Dickey and Fuller 1979). So in this paper the maximum lag allowed in the information criterions is fixed at 15, given monthly nature of the data. The minimum lag possible is the minimum lag selected by any of the information criterions. If at this lag there is serial correlation problem lags are added until the error term becomes independent. And the maximum addition of lags is determined by the maximum lag selected by any of the information criterions. It was observed in some prices it may not be possible to find normally distributed error terms up to the maximum lag selected and it was necessary to add lags but the test becomes weak and it fail to reject unit root even in first difference of the prices. So the ADF test is done by depending on asymptotic distribution which demands independent error terms only. Given these facts let's focus on the unit root analysis of the level and first difference data in order to find the possibility of one or two unit roots which are common in economic data.

3.2. ADF Unit root test for 8 white wheat whole sale prices

The stating point of unit root analysis is observation of the level data dynamics from graphic presentation. This will enable us to interpret the ADF test result accurately without sinking in to circular reasoning. As can be seen from figure 3 below any of the prices did not have either random or deterministic trend. However they have none zero mean. Given these facts we have to check if the none-zero mean is caused by stationary series around drift or unit root series around zero. But for robustness of the result let's start from the more general test of Φ_3 .

Table 1 ADF test for level data of 8 white wheat markets

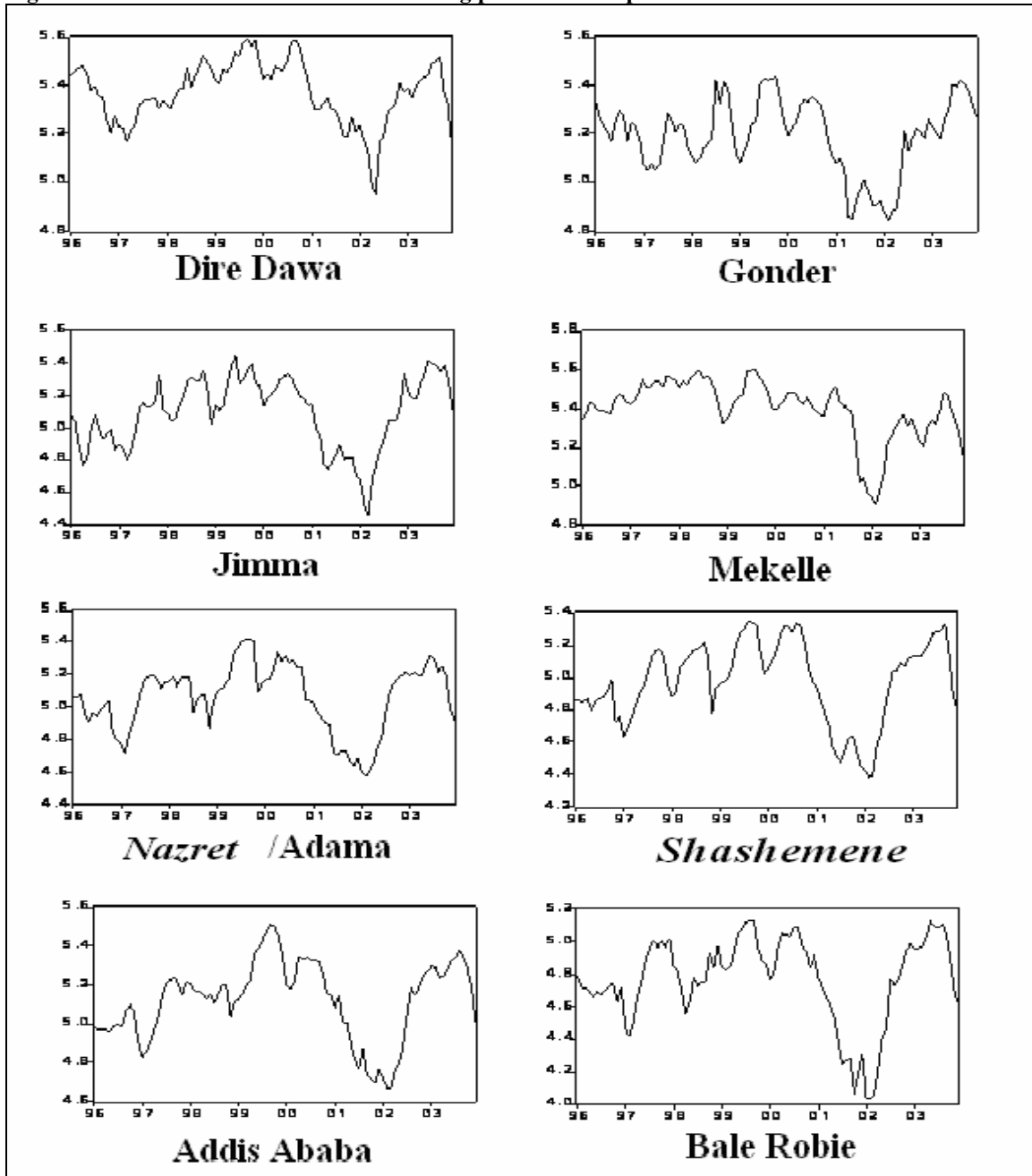
Market	With out drift		With drift			With trend		
	Lag	t_{df}	Lag	t_{α}	Φ_1	Lag	t_T	Φ_3
Addis Ababa (A)	1	-0.121	1	-2.235	6.94***	1	-2.179	2.6
Bale Robe (B)	0	-0.282	0	-1.798	1.63	0	-1.798	1.65
Dire Dawa (D)	1	-0.607	1	-2.078	2.32	0	-1.92	1.97
Gonder (G)	5	-0.032	3	-2.799*	3.92	1	-2.71	3.72
Jimma (J)	0	0.04	0	-2.037	2.08	0	-2.036	2.07
Mekelle (M)	5	-0.395	2	-2.366	2.92	1	-3.221*	5.44
Nazret (N)	4	-0.164	3	-3.312**	3.33	0	-1.848	1.75
Shashemene (S)	1	0.203	1	2.51	3.15	1	-2.478	3.2

Note 1 * Significant at 10%, ** significant at 5% and *** significant at 1% level.

The joint test of the trend coefficient and the unit root coefficient under Φ_3 shows that the null of unit root around drift can't be rejected for all eight markets. However the conclusion can't be accepted at its face value since the test is not consistent with the data generating process and given serial correlation was observed in all possible lags (not reported here). When there is serial correlation in error terms the Dickey-Fuller or DF

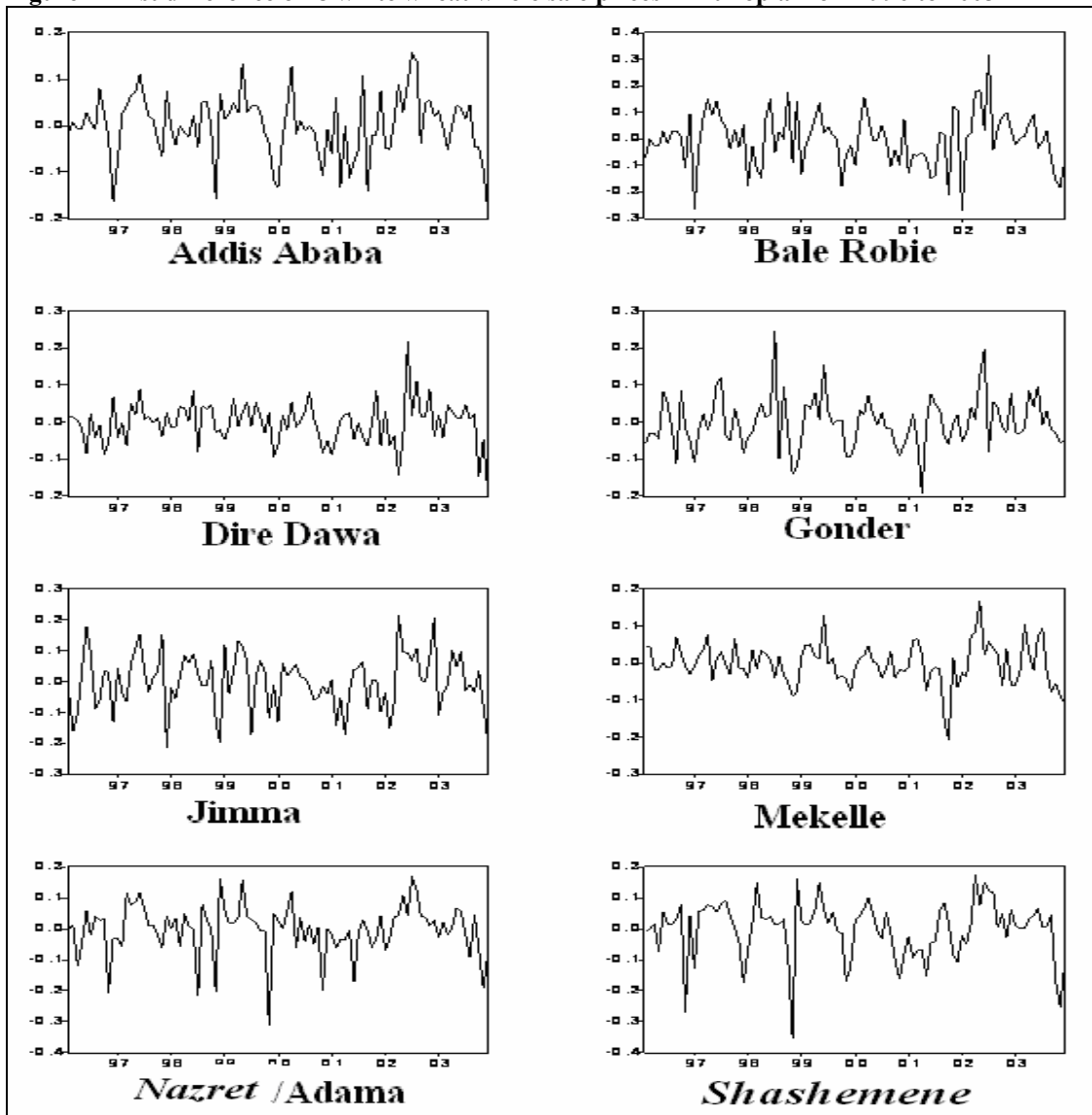
distribution used to make inference is not appropriate and when the test is not consistent with the data generating process the ADF testes have weak power to reject the null. One way or another, the conclusions have to be accepted with great reservation. However assuming there is trend in the data and t_{τ} is appropriate test the null of unit root around trend is rejected at 10% level for Mekelle but not for others. If this test result is right there should be deterministic trend in level of Mekelle, which is not the case. So we have to reject the Mekelle's test result, too.

Figure 3 levels of 8 white wheat whole sale log prices in Ethiopia from 1996 to 2003



When the Φ_1 version of the F test is used the null of unit root around zero is not rejected even at 10% level for all but Addis Ababa. For Addis Ababa the null is rejected at 1% level which could imply that there is either unit root around drift, drift with stationery series or unit root around drift. If there is unit root around drift there must be stochastic trend in level data. However figure 3 above clearly shows that there is no trend in level of Addis Ababa. The second option is that the data is stationary around drift but the more power full test of t_α under such assumption is not rejecting unit root around drift at 10% level. So the only logical conclusion is that the data is following unit root around zero. But under such assumption both Φ_1 and t_α have weak power so it have to be proven by more power full ADF test of t_{df} .

Figure 4 First difference of 8 white wheat whole sale prices in Ethiopia from 1996 to 2003



Assuming there is drift in the level data of Gonder at 10% and Nazret at 5% level are having stationary series. But since the existence of drift is rejected by Φ_1 test these result

can't be accepted. So as can be judged from the visual inspection of figure 3 and the more general F version testes the most appropriate test is ADF with out drift or t_{df} . And under this test the null of unit around zero can't be rejected at 10% level for all markets. Therefore the most logical conclusion is that all prices are having at least one unit root.

Even though two unit roots are less common in economics the existence of two unit roots can be tested by using the first difference as level data and making the same analysis on first difference of the data. But for better conclusion, let's observe the graphic presentation of first difference of level price given in figure 4, above. And as can be seen from figure 4 above the data is more of stationary around zero. But most importantly there is neither deterministic nor stochastic trend on it. Even the data is fluctuating around zero so the first differences of the prices are having zero mean. This means the appropriate test is ADF with out drift or t_{df} . But let's see if the testes can back the above visual conclusion.

Table 2 ADF test for first difference of level data of 8 white wheat markets

Market	With out drift		With drift		
	Lag used	t_{df}	Lag used	t_{α}	Φ_1
Addis Ababa (A)	3	-3.409***	3	-3.369**	5.75**
Bale Robe (B)	3	-3.604***	2	-4.08***	8.35***
Dire Dawa (D)	1	-4.739***	1	-4.736***	11.31***
Gonder (G)	4	-5.192***	4	-5.157***	13.32***
Jimma (J)	3	-4.806***	3	-4.79***	11.48***
Mekelle (M)	4	-4.745***	4	-4.721***	11.2***
Nazret (N)	3	-3.334***	3	-3.312**	5.5**
Shashemene (S)	2	-4.864***	1	-4.833***	11.71***

Note 2 * Significant at 10%, ** significant at 5% and *** significant at 1% level.

Since the first difference does not have any trend Φ_3 is not appropriate but most importantly for all markets when trend is allowed it was not possible to find independent error terms at what ever lag. So it is dropped from the analysis. As can be seen from table 2 above the null of unit root around zero is rejected at 1% level for all markets except two. For these 6 markets the null of unit root with drift or with out drift is also rejected with 99% confidence. Means for these 6 markets there is no second unit root. For Addis Ababa and Nazret the null of unit root around zero under Φ_1 and unit root around drift under t_{α} is rejected at 5% level but not at 10% level¹⁰. However given the data is having zero mean it is known fact that t_{α} and Φ_1 have weak power compared to t_{df} . Moreover

¹⁰ If we make conclusion these testes are right the conclusion will not be consistence with visible pattern of the data. The null can be accepted due to three reasons. First both the drift and unit root term are zero. Means the data is following unit root around zero. But the more power full test under such assumption or t_{df} is rejecting the existence of unit root in first difference. Second the data could be stationery around drift but it need to have none zero mean which is not observed in the figure. The third option is that the data is following unit root around drift which implies there is trend in level data which is not the case.

the null of unit root around zero based on t_{df} is rejected at 1% level, so these markets are also accepted as having only one unit root, too.

In general the logical conclusion is that all prices are following unit root but the existence of two unit roots, which is less common in economics is highly improbable in the wheat prices of Ethiopia. But it is rational to keep reservation for price of Addis Ababa, Mekelle and Nazret. However the search procedure used in this paper will buffer them out in process of searching for rule of one price, if they are stationary. So there is no logical reason to exclude them in the cointegration analysis. This is so since the evidence toward single unit root is much stronger than to the contrary. Given these facts now let's focus on the VECM next.

3.3. Cointegration analysis to search for markets under rule of one price

In this paper the search for cointegrating prices will start by identifying two markets prices which share the same common trend given white noise innovations. Then third, fourth and more markets are added, if the new market can share the same single common trend with cointegrated markets in lower dimension. But to allow for possibility of strength reversal all possible permutations are also checked to see if markets un-cointegrated in lower dimension can form cointegration in higher dimension. On all steps the assumption of normality and independence is assured by using appropriate testes specified above. Moreover four different information criteria are used to see, if the selected combination of markets has lag order backed by any of the information criteria. And for market combinations with one common trend, lag backed by information criteria and normally and independently distributed error vector ARCH/GARCH test is done to make sure they are following white noise distribution. Once $n = h + 1$ markets with h cointegrating vectors are found Johansen VECM will enable us to identify the space spanned by the cointegrating vectors not the cointegrating vectors themselves. So appropriate normalization will be imposed based on proximity of the actual estimation to the ideal assumptions assumed in the model, mainly the normality of the error vectors. Even after the $n = h + 1$ markets and their appropriate lag order is identified, out of P_n^n permutation of markets only $n - 1$ permutations are relevant and others are just redundant. Moreover JB normality test is observed to be dependent on market order. So the order with highest probability of being normally distributed is selected as right order and reported in each table.

There are two important implicit assumptions in the cointegration analysis used in this paper. First transaction cost is stationary and second there is only unidirectional trade. The first problem is related to the fact that cointegration test may reject cointegration when they are actually cointegrated due to existence of unit root in transaction cost. However as rightly stated by Rashid (2004) most cointegration studies did not fail to find cointegration among large number of markets, including this paper. So the exclusion of transaction cost due to lack of data is not causing series problem in the cointegration analysis. Second the existence of trade reversal demands switching regression. However observation of the price pattern shows that most prices are free from trade reversal problem and markets observed to be more susceptible for trade reversal are also observed

to be highly cointegrated to each other¹¹. So trade reversal is also not found to be a series problem for this paper. Now let's focus on the estimation of the VECM.

There are 5 different versions of Johansen (1988, 1991 and 1992) VECM. One version of the model did not allow for any deterministic component, the second will allow restricted constant in the cointegration equations only, third will allow unrestricted constant, the fourth will allow for restricted trend in the cointegration equation and unrestricted constant in the error correction model and the last one will allow unrestricted trend in the VECM. Given lack of none zero transaction cost and none quadratic trend in level data the most appropriate models are three. The first is the restricted constant to allow for constant transaction cost with un-trended level data. The second is unrestricted constant which allows trended level data and constant transaction cost. The third is restricted trend which allows trend in transaction cost and level data.

In this paper the unrestricted constant model is used not because the level data is visibly trended but in order to use seasonal indicators which are found to be very important. As can be seen from table 3 below ignoring the seasonal indicators the restricted constant model is more appropriate. However once seasonal indicators are used the one with unrestricted constant will become more robust in representing the data. So the use of unrestricted constant is justified not because the level data have linear trend but because seasonality is widely observed in the data and seasonality can't be controlled in restricted constant model.

Table 3 Likelihood test for unrestricted constant two markets

Combination	With out seasonal indicators		With seasonal indicators	
	LM statistics (1)	Prob.	LM statistics (22)	Prob.
J - A	0.0011	0.96	46.5171	0.002
B - A	0.019	0.891	48.308	0.001

note 3 11 centered monthly dummy and 3 centered seasonal dummy are used but 3 are dropped due to multicollinearity so there are 11 dummies in each equation.

note 4 A – Addis Ababa, B –Bale Robe, J – Jimma

Moreover when restricted constant is used it was possible to find up to four markets which are following one common trend. But with unrestricted constant and seasonal indicators it was possible to find up to 6 markets which are following one common trend. For restricted trend not only the model demanded longer lags but also it was not able to find behind 3 markets which are following one common trend. So in order to control seasonal variations and to use model which is representative of most of the markets the unrestricted constant model is selected in these paper¹². So let's analyze the search result below.

After searching for all possible permutation of markets in the lag interval selected by the information criterions three market combinations of two markets are found to have lag

¹¹ See working paper version of this paper in Taddese (2009)

¹² Detailed analysis of the three models can be found in working paper version of the paper in Taddese (2009)

order backed by some of the information criterions, normally and independently distributed error vector and one common trend. The null of two common trends or 0 rank is rejected for the three combinations at 1% level. Moreover the null of 1 rank or 1 common trend can't be rejected at 5% level for all of them. So the logical conclusion is that the three combinations of two markets are following one common trend.

Table 4 Trace test for cointegration rank

Markets	Lags	Rank				
		0	1	2	3	4
A-B	1	24.021	1.998			
J-A	1	24.716	1.819			
D-B	1	20.3525	3.7354			
J-A-B	1	46.47	21.99	1.71		
J-D-B	7	40.23	20.1	2.62		
J-D-B	1	41.079	21.093	3.287		
A-B-G-J	1	69.09	44.49	20.47	1.64	
B-G-J-N	1	64.53	42.35	20.46	1.71	
B-J-N-S-G	1	108.339	66.0289	41.605	21.3111	1.6685
G-B-J-A-S	1	105.2824	65.6843	40.7827	20.0811	1.7859
<u>Critical values</u>						
		Number of common trends (p – r)				
Upper tail probability		1	2	3	4	5
5%		3.76	15.41	29.68	47.21	68.52
1%		6.65	20.04	35.65	54.46	76.07

note 5 A – Addis Ababa, B –Bale Robe, D – Dire Dawa, G –Gonder, J – Jimma, N-Nazret and S-Shashemene

As can be seen from table 5 below the three combinations' lag is also backed by SBIC and for two of them their lags are also backed by HQIC. Although other criterions are not backing their lag, we can't reject their specification. This is so since the criterions never select the same lag for any of the dimensions given above. A robust study on lag selection by Gonzalo and Pitarakis (2000) did show that HQIC and SBIC have high probability to under fit and AIC have higher tendency to over fit in small and moderate samples. So the testes are not taken as perfect predictors of the lag order but as minimum and maximum lag identifiers. Based on this logic there is no reason to reject these market combinations. Based on JB normality test the null of normality can't be rejected at 10% level for all and based on LM test for serial independence the null of independently distributed error vectors can't be rejected at 45% level. The logical conclusion is that the strongest bivariate cointegration is found between Central market of Addis Ababa and surplus market of Bale Robe in South in one direction. In other direction another strong cointegration is observed between Deficit market of Jimma in south west, which is also important source of Coffee and Chat which are important export commodity for the country, and central market of Addis Ababa. The third combination is between deficit market of Dire Dawa in East and central market of Addis Ababa. Again Dire Dawa is not only good source of Chat and Coffee but also important export hub for the economy.

As can be seen in appendix 1 the combinations which include Addis Ababa are not having any time varying heteroskedasticity or ARCH/GARCH effect. So for both combinations which include the central market and major deficit market with effective demand¹³ in one direction and major surplus market in other direction are found to have one common trend with white noise error vector. However the cointegration of deficit center of Dire Dawa in East and surplus market of Bale Robe in South are observed to have some ARCH/GARCH problem mainly in the Dire Dawa equation. At 5th lag which is the highest lag selected by all information criterions Dire Dawa's equation is having ARCH/GARCH effect which is significant at 1% level.

Table 5 lag order, normality and serial correlation testes

Markets	Lags	Lag selection by different information criterions				Jarque - Bera test for Normality			LM - Serial correlation test		
		FPE	AIC	HQIC	SBIC	Statistic	DF	Prob	Statistic	DF	Prob
A-B	1	2	2	1	1	5.806	4	0.214	38.863	60	0.984
J-A	1	3	3	3	1	1.523	4	0.823	60.506	60	0.457
D-B	1	5	5	1	1	7.598	4	0.107	53.675	60	0.705
J-A-B	1	5	5	1	1	3.752	6	0.71	119.256	135	0.831
J-D-B	1	5	7	1	1	6.416	6	6.416	129.391	135	0.62
J-D-B	7	5	7	1	1	2.119	6	0.908	134.507	135	0.496
A-B-G-J	1	7	7	1	1	12.223	8	0.142	268.54	240	0.099
B-G-J-N	1	2	9	1	1	12.350	8	0.136	263.949	240	0.138
B-J-N-S-G	1	2	6	1	1	13.012	10	0.223	370.503	375	0.556
G-B-J-A-S	1	2	6	1	1	15.308	10	0.121	379.025	375	0.432

note 6 A – Addis Ababa, B –Bale Robe, D – Dire Dawa, G –Gonder, J – Jimma, N-Nazret and S-Shashemene

However the impact of ARCH/GARCH effect is found to be very marginal in Monte Carlo study by Lee and Tse (1996). For example when there is no heteroskedasticity the power of trace test with 100 observations, which is close to the observations used in the study, is 98.56%. However if there is ARCH/GARCH effect with the first parameter equal to 0.1 and second parameter equal to 0.8 the power will decline marginally to 97.97%. However if the first parameter is increased to 0.3 and the second reduced to 0.6 the power will decline to 95.94%. In general the impact of ARCH/GARCH is to reduce the power of the rank test defined in terms of rejecting false cointegration but the impact is very marginal. And the impact is proportional to the size of the first ARCH parameter in ARCH/GARCH regression. So ARCH model with 5 lag have to be estimated in the error term of Dire Dawa to observe the size of the first ARCH coefficient.

The first parameter in OLS estimation is found to be very small with value of -0.0055861 and the over all sum of the five coefficients is also only 0.2100066. So based on OLS result there is no series ARCH/GARCH problem. However since the first coefficient is negative it can't be taken at face value. To avoid negative coefficient in ARCH

¹³ Since Jimma is located in area where significant portion of coffee and Chat export, the two major export commodity of the country, is originating and both are produced by small scale farmers. So there is effective demand than mere demand for white wheat.

regression, it is re-estimated using maximum likelihood estimation with restriction on the coefficients¹⁴. And the value of first coefficient turns out to be numerically and statistically very close to zero. And the sum of eight coefficients is 0.220036331 and mainly caused by third coefficient in ARCH regression. So what ever ARCH/GARCH effect there is, it is not that strong to introduce large bias in the power of the rank test. So the combination is accepted as following one common trend.

The logical conclusion at two dimensions is that the strongest cointegrations are found between central market of Addis Ababa and two important markets. In one direction an important wheat surplus market, i.e. Bale Robe which is located in wheat producing high potential area in south. In other direction Addis Ababa is cointegrated with important deficit market, i.e. Jimma with real purchasing power in south west side of the country, dominated by coffee and chat producer small scale farmers. Moreover the deficit market of Dire Dawa in East, which is also important export hub, is found to be cointegrated with major surplus market of Bale Robe at South.

The next step is to search for third market which is sharing one common trend with either combination. However to allow for possibility of strength reversal all permutation of three markets are tested for one common trend. This will eliminate the unnecessary assumption which states that all higher dimension cointegration have to be based on cointegrated markets in lower dimension¹⁵. Observing table 4 it is clear that strength reversal was not observed in the markets as third dimension cointegrations with one common trend are developed out of the four markets found to be cointegrated at 2nd dimension.

One common trend is found between central market of Addis Ababa, surplus market of Bale Robe and Deficit market of Jimma. As can be seen from table 5 and appendix 1 the error vectors are found to be normally and independently distributed with constant variance. So the critical assumptions of rank test are satisfied so there is no doubt about rank test result that the markets are following one common trend. And the lags used are backed by HQIC and SBIC but note others. However if we expect the information criterions to give the same result it would be impossible to find one combination since they will pick different lags in almost all cases.

However the second combination of three markets is found between Jimma, Bale Robe and Dire Dawa at 1st and 7th lag which are backed by some of the information criterions (see table 4 and 5 above). At 7th lag the error vectors are found to be normally and independently distributed for all possible lags from 1 to 15th lag. However ARCH/GARCH effect is observed in Dire Dawa equation (see appendix 1). To see how large the first ARCH parameter is OLS regression is used but the first coefficient turn out to be small but negative (-0.0702418). Imposing restrictions on the parameters to make

¹⁴ in GivWin software with GARCH version 1 programming

¹⁵ As was stated before since lower dimension estimation of higher dimension systems will generate omitted variable bias (González-Rivera and Helfand 2001), it is possible that even if x and y are highly cointegrated in 2nd dimension, in 3rd dimension a, b and c can be more cointegrated than x, y and any third market. This is termed as strength reversal in this paper.

the conditional variance always positive the Best unbiased estimator based on maximum likelihood estimation is used and the first coefficient turn out to be as small as 0.0182917 with total sum of the 5 parameters as small as 0.018378938. So ARCH effect observed is not that strong enough to introduce a doubt in to the conclusion that the three markets are following one common trend or are under rule of one price.

However as can be seen in table 4 above, the 3 markets are also observed to have one common trend in first lag, too. The null of 0 rank or 3 common trends and 1 rank or 2 common trend are rejected at 1% level. However the null of 2 rank or 1 common trend can't be rejected at 5% level. So the markets are following one common trend at first lag. Table 5 also shows that there is no serial correlation and normality problem. However table 5 is hiding one fact that serial correlation test is given at 15th cumulative lag and in all combinations stated before, but one, serial correlation was not observed in all levels from 1 to 15th lags, though only at 15th cumulative lag is presented for presentation convenience¹⁶. However the combination of Jimma, Bale Robe and Dire Dawa was observed to have serial correlation at some lags. So it will make difference which lag is selected for test result. In such case two addition statistics are given in appendix 2. First the highest probability of serial correlation observed in any cumulative lag from 1 to 15th. In case the statistics is significant additional statistics is given in cumulative lag selected by information criterions¹⁷. And for these markets the highest serial correlation is observed at 9th cumulative lag but still it is not significant even at 15% and there is no need for second statistics. So it is logical to accept this market combinations at first lag are having white noise distribution with minor but not series possibility of serial correlation at some lags. The advantage of 1st lag is that as can be seen in first Appendix the ARCH/GARCH effect is avoided. So either we take 1st or 7th lag, it is more probable that Jimma, Bale Robe and Dire Dawa are following one common trend though their cointegration is less strong compared to the cointegration of Addis Ababa, Jimma and Bale Robe.

Given the above evidence the logical conclusion is that two common trends of three markets are found among the four markets. One combination includes major deficit market with effective demand (Jimma), major surplus market (Bale Robe) and central market of Addis Ababa. And the second combination is between Jimma, Bale Robe and Dire Dawa an important export hub and important source of coffee and chat export. This is in line with methodology used by Gonzalez – Rivera and Helfand (2001) and Rashid (2004) to start the search from dominant markets in the economy.

The search for four markets generated two combinations of markets one that is build in existing markets and one that excludes important markets, which implies the possibility of strength reversal. As can be seen from table 4 above the null of 4, 3 and 2 common

¹⁶ Testes are done for each lag but it is presented at 15th cumulative lag. Since each lag is independent and have chi2 distribution their sum or their cumulative value will also have chi2 distribution

¹⁷ It is observed that in these case most of the information criterions were picking the same lag. So it could be possible that the performance of the information criterions is dependent on white noisiness of the data. So understanding performance of the criterions when the data is not white noise could be important research area since they are developed under white noise data. Başçi and Zaman (1998) did make such analysis for one dimension but needs to be extended to higher dimensions.

trends are rejected at 1% level but not the null of 1 common trend even at 5% level. So assuming there is no distributional problem both combinations are having one common trend. In one direction the combination Addis Ababa, Bale Robe and Jimma added deficit market of Gonder located in North West side of the country. Gonder is an important export hub for oil seed export, which is becoming important export commodity in the country and at the same time is also high potential area, for example in maize production. The above market combination is again in line with early papers implicit assumption that strength reversal is not a series problem. However if we follow the method of the early papers it would not be possible to identify the second combination of markets which are following a rule of one price.

Bale Robe and Jimma by dropping central market of Addis Ababa did add deficit market of Gonder in North West and secondarily central market of Nazret/Adama at the center. Nazret/Adama is the second larger city in the country, where major export commodities are stored before they can be exported given its strategic location. For both markets the null of normality can't be rejected even at 14% level. However there is evidence of serial correlation in both combinations and mainly in the first combination. At 15th cumulative lag the null of independence is rejected at 10% but not at 9% for combination that include Addis Ababa. For the second combination the null is not rejected at 13%. Unfortunately there was some evidence of serial correlation at some lags. As can be seen from appendix 2 for combination which includes Addis Ababa the highest serial correlation is observed at 9th cumulative lag which is significant at 5%. And for combination which includes Nazret the highest serial correlation is observed at 8th cumulative lag which is significant 10% level. So the problem is more series in combination which includes Addis Ababa, though there is some evidence of serial correlation in both combinations. However the serial correlation test is dependent on lag used and information criterions are used to select the appropriate lags and for selected lags cumulative serial correlation testes are given at bottom of Appendix 2. The selected lag for both is one and for both the null of independently distributed error vector can't be rejected at 20% level. So even though it is not logical to reject the combinations as not following a single trend since there is no conclusive evidence in that side, their cointegration has to be accepted with some reservation. Additionally there is no evidence of ARCH/GARCH effect as can be seen from appendix 1.

However a very important departure is observed in the above result as that possibility of strength reversal is observed among the markets. The market combination which includes Nazret though not based on combination found in third dimension is having more reliable result than the one that include in Addis Ababa, which is also based on the one common trend observed in third dimension between Jimma, Bale Robe and Addis Ababa. If both market combinations departure with out cointegrating in to one common trend, it could imply that the mythology used by early papers, i.e. Gonzalez – Rivera and Helfand (2001) and Rashid (2004), is not only theoretically but empirically fallowed¹⁸.

¹⁸ It will become clear latter on though theoretically the methodology is not sound it is observed to work in Ethiopian wheat market as was the case in Brazil rice market (Gonzalez – Rivera and Helfand 2001)

At 5th dimension both combinations which are found to be following one common trend at 4th dimension are also observed to add the surplus market of Shashemene at south central. Shashemene is another important grain market in the economy, which is also an important whole sale market for export of coffee and chat originating in southern Ethiopia. As before except for null of one common trend the null of more than one common trend is rejected at 1% level. However the null of one common trend can't be rejected at 5% level, leave alone at 1% level (see table 4, above). So assuming both combinations are correctly specified, they are following one common trend or the markets in each combination are under rule of one price.

Their lag is backed by both HQIC and SBIC but not others as usual. The null of normality can't be rejected at 12% for both and null of serial correlation can't be rejected at 15th cumulative lag at 43% level (see table 5, above). However at some lags evidence of serial correlation was observed. So cumulative serial lags are tested at each possible cumulative serial lag from 1st to 15th. Fortunately serial correlation was not observed to be series problem. This is so because as can be seen from appendix 2 the highest serial correlation was observed at 9th lag for both and both statistics are insignificant up to 14% level. However in both combinations ARCH/GARCH effect was observed in equation of Shashemene and to some extent Gonder.

In the combination which includes surplus markets of Bale Robe and Shashemene, deficit market of Gonder and Jimma and Secondarily central market of Nazret the existence of ARCH/GARCH effect is not rejected at 10% but at 9% for Gonder and 1% for Shashemene. ARCH testes are done to both markets, in which Shashemene coefficient is observed to be as large as 0.482993 and the relative value for Gonder is 0.1988642. So possible ARCH/GRACH effect is expected to reduce the power of the rank testes marginally in this combination. Means rank test have tendency to find cointegration when there is none. In the second combination which include Addis Ababa, Bale Robe, Gonder, Jimma and Shashemene the same ARCH/GARCH problem is observed at similar level of significance in both Gonder and Shashemene. And ARCH/GARCH test is done and the first coefficients of Shashemene and Gonder turn out to be 0.4500022 and 0.2046188, respectively. So even though the conclusion have to be accepted with higher reservation the markets are accepted as following one common trend due to two facts. First the impact of ARCH/GARCH effect is to reduce power of rank test by very small percentage points. Second in this paper than conventional 5% level insignificance 1% level insignificant is used in order to reject any null. So it is believed that the use of 1% significance before accepting, if affected by ARCH/GARCH effect will still hold at 5% level. The study by Tse (1996) did show that when first coefficient is increased from 0.1 to 0.3 the power of the test will decline from 97.97% to 95.94%, merely 2 percentage point decline in power. Even if the first coefficient is increased to 0.5 we can't expect significant decline in power. So even though it is very logical to doubt, if Shashemene is part of the one price system, there is no very strong evidence to reject it, than doubt it.

The finding by Gonzalez – Rivera and Helfand (2001) shows that in Brazil rice market the boarder of one price system dependent on distance from capital city or central market. Taking this result in to account in Rashid (2004) adoption of the methodology to Uganda

distance was used as determining factor in order of inclusion. However in this study it is found that distance could be important but not the most important factor in determining the border, if there is any border, of the one price system per se. Shashimiene which is located in 306 km from Addis Ababa with one of the best quality roads in the country is included in to the rule of one price after Gonder and Bale Robe which are located at 379 and 430 km from Addis Ababa. Actually to reach Bale Robe you have to pass through Shashimiene and Gonder can be reached after traveling one of the few un-convent roads in the country, at that time. Taking Nazret in to account it started to be part of one common trend only at fourth dimension, though it is just 100 km from the capital city of Addis Ababa. So in under developed market system like Ethiopia, which is facing high levels of market failures and missing markets (Eleni 2001 and Eleni et al 2003), other complementary institutions are expected to play a critical role in determining cointegration in addition to transportation convince. So the level of market failures and associated institutions developed to solve the market failures may be as important as transportation convince, if not more important.

Using Johansen VECM and demanding white noise error vectors, it was not possible to find combination of 6 markets which are following one common trend. This could imply that the search procedure used by early papers could find the combination which include Addis Ababa but not the combination which includes Nazret, so it is both theoretically and empirically followed. However as it will become clear in common trend analysis, below, both combinations are following one common trend. Means the problem is on the rank test which is developed for white noise error vectors not with the search procedure used by preceding authors.

3.4. Identification of single common trend and its determinants

Up to this point markets which are ruled by one price are identified. The next step for robust policy recommendation needs the estimation of the single common trend which is keeping these markets together. Moreover identification of markets which are having major impact on this common trend will result on identification of markets where effective policy intervention can be done with least possible administrative cost. The methodology used is based on permanent and transitory decomposition of cointegrated vectors developed by Gonzalo and Granger (1995).

In the analysis below F_A means the common trend which is cointegrating the five markets which include the central market of Addis Ababa. F_N means the common trend which is keeping the five markets which include Nazret under rule of one price. For the first combination of markets which include Addis Ababa the common trend is estimated as following

$$F_A = - 4.3534381A - 9.2153955B - 6.1413652J - 4.8007328G + 11.096666S$$

As can be seen above the first and second main determinants of the common trend are producer centers of Shashemene and Bale Robe, respectively. The next strong impact is coming from deficit market of Jimma. Both Gonder and Addis Ababa are having the lowest impact on common trend, respectively.

Table 6 the statistical significance of impact of markets in the rule of one price or common trend on market combination which includes Addis Ababa

Null	Statistics	Degree of freedom	probability
$\mathbf{a}_{\perp A} = 0$	1.398923658	1	0.236904031
$\mathbf{a}_{\perp G} = 0$	1.385296	1	0.239201
$\mathbf{a}_{\perp A} = \mathbf{a}_{\perp G} = 0$	4.183142863	2	0.123492923
$\mathbf{a}_{\perp J} = 0$	27.88413	1	0
$\mathbf{a}_{\perp A} = \mathbf{a}_{\perp G} = \mathbf{a}_{\perp J} = 0$	34.85149313	3	0

note 7 A – Addis Ababa, B –Bale Robe, G –Gonder, J – Jimma and S- Shashemene

Table 6 above clearly shows that the impact of both Addis Ababa and Gonder in the common cointegrating trend is statistically insignificant. The economic implication is that the deficit market of Gonder and the central market of Addis Ababa are price takers as the common trend is not determined by them. Means the market clearing price is mainly discovered in surplus markets of Shashemene and Bale Robe and one deficit market of Jimma in the period of 1996 to 2003. When the second combination, which includes Nazret, is considered still producer centers are observed to have more say in price formation in the period of 1996 to 2003. The highest impact is coming from surplus market of Shashemene followed by another surplus market of Bale Robe.

$$F_N = -3.2450884N - 9.2902753B - 6.6893742J - 4.7592718G + 11.280918S$$

From deficit markets the highest impact is coming from Jimma followed by Gonder. And the secondarily central market of Nazret is having the weakest impact on the common integrating trend. Table 7, below, is providing statistical justification about the conclusion that the important markets in the price formation or the determination of the common trend are Shashemene, Bale Robe and Jimma only.

Table 7 the statistical significance of impact of markets in the rule of one price or common trend on market combination which includes Addis Ababa

Null	Statistics	Degree of freedom	probability
$\mathbf{a}_{\perp N} = 0$	0.651329121	1	0.419637885
$\mathbf{a}_{\perp G} = 0$	1.00927	1	0.315078
$\mathbf{a}_{\perp N} = \mathbf{a}_{\perp G} = 0$	2.311928531	2	0.314753884
$\mathbf{a}_{\perp J} = 0$	30.20327	1	0
$\mathbf{a}_{\perp N} = \mathbf{a}_{\perp G} = \mathbf{a}_{\perp J} = 0$	34.17580065	3	0

note 8 B –Bale Robe, G –Gonder, J – Jimma, N-Nazret and S- Shashemene

A restricted version of the common trend is estimated by dropping Addis Ababa and Gonder from first combination and Nazret and Gonder from the second combination. And both combinations are observed to have the same common trend given below.

$$F_A = F_N = -10.66157741B - 8.422869842J + 10.11121128S$$

So both surplus markets of Shashemene and Bale Robe are having more or less the same impact on formation of the common trend or price fixation followed by deficit market of Jimma. This implies two things first the search procedure that is followed by early papers though theoretically unsound, it is found to work for Ethiopian white wheat whole sale markets. And this was the case for Brazil rice market studied by Gonzalez – Rivera and Helfand (2001). The second important points is that the Johansen (1988, 1991 and 1992) VECM developed for white noise errors is not adequate for all data generating processes and we may reject cointegrated markets since they have none white noise error vector. Means there is need for development of VECM which is not dependent on distribution assumptions. Having good understanding of the long run, it is now time to analyze the short run dynamics between the markets in order to have clear policy prescription for grain market price stabilization effort.

3.5. Persistence profile and adjustment parameters among cointegrated markets

The use of persistence profile (Pesaran and Shin 1996) has two basic advantages. One is related to its capability to summarize the impact of both adjustment parameters and lagged shocks in to single index. Second is related to its insensitivity to order of markets used in fitting the VECM for given identification assumption; which was not the case for impulse response function. However it is sensitive to identification assumption imposed in the model. In this paper there are two possibilities. One is to use identification assumption with highest probability of normality as they are reported in preceding tables or the second option is to use identification against the central market which is found to be an important transit market in early studies (Gebremeskel 1997 for example). The second one is very use full but the first one is more logical given the over all VECM is dependent on white noise distribution. However since major difference is not observed between the two identification assumptions the more informative identification against the central market of Addis Ababa for one combination and Nazret for another combination are used in this paper¹⁹.

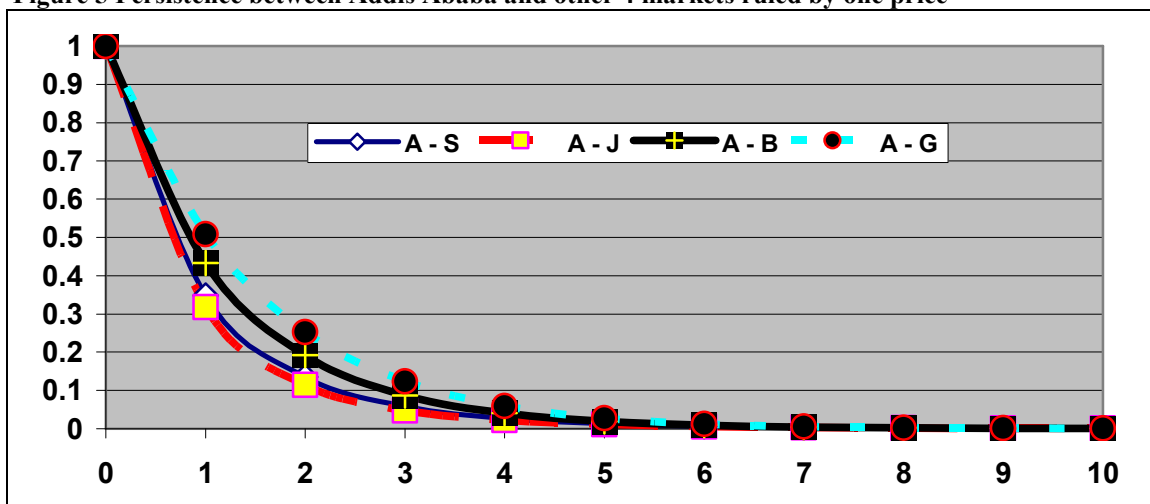
Understanding the persistence of system wide shock will create understanding on short run behavior of markets. VECM and the identification of common trends were critical in mapping the long run dynamics of the market but effective intervention demands clear understanding of both short run and long run dynamics. That is why the persistence profile is very are important complement to cointegration and common trend analysis. However not only the reaction to system wide shocks but also the pattern of reaction to shocks initiated in given cointegrating equation is very informative for clear understanding of market's short run behavior. These are related to adjustment parameter(**B**) defined in equation 3, above. Given the above facts as back ground let's start the short run analysis from the first combination which includes central market of Addis Ababa.

¹⁹ The result of both identification assumptions can be found in the working paper version of these paper in Taddese (2009)

3.5.1. Market combinations which include Addis Ababa

As can be seen from figure 5 and table 8 below in the first combination of markets which include Addis Ababa the lowest persistence is observed in customer center of Jimma. In Jimma and in first month more than 65% of a system wide shock is corrected and mean²⁰ persistence is 66% of a month or around 20 days. Means it will take 20 days to eliminate most of the system wide shock. The worst is observed in another customer center of Gonder which is located in considerable distance from the four markets to North West side of the country. The first month persistence in Gonder is close to 51% and it will take approximately 29 days to neutralize most of the system wide shock on average. Both producer centers are in the middle in which Shashemene is having the next low persistence with first month persistence of just less than 35% and as result it will take approximately 20 days to eliminate most of the system wide shock. However Bale Robe performance is close to the performance of Gonder than either Jimma or Shashemene. On average it is observed to take 25 days to eliminate most of the system wide shock with first month persistence of 43%.

Figure 5 Persistence between Addis Ababa and other 4 markets ruled by one price



note 9 A – Addis Ababa, B –Bale Robe, G –Gonder, J – Jimma and S- Shashemene

Following Gonzalez – Rivera and Helfand (2001) if we assume persistence profile is measure of the degree of market integration, Addis Ababa is more cointegrated with Jimma and Shashimene than Bale Robe and Gonder. Moreover Jimma (330 km) and Shashimene (306 km) are located in close distance from central market of Addis Ababa compared to both Gonder (379 km) and Bale Robe (430 km). However in addition to distance road quality seems to play a very important role. Given the fact that both Jimma and Shashimene are strategically important to the major export market are supplied with good quality roads, which is not the case in both Gonder and Bale Robe, at that time. So even though distance and road quality are not the critical factors determining the inclusion of markets to the rule of one price; once the markets are under rule of one price the more close they are located the more cointegrated they will be.

²⁰ On averaging since months are weighted by persistence in each month this is not simple average it is weight average.

Table 8 Summary statistics for Persistence between Addis Ababa and other 4 markets

Market combination	A – S	A – J	A – B	A – G
Mean persistence in months	0.663446	0.606972	0.815844	0.964209
Mean persistence in days	19.90338	18.20916	24.47532	28.92627
First month Persistence (%)	0.34834	0.318259	0.433251	0.507999

note 10 A – Addis Ababa, B –Bale Robe, G –Gonder, J – Jimma and S- Shashemene

Adjustment parameters focus in short run reaction of markets to shocks initiated in given cointegrating equation between two markets. This will be useful in identifying markets which are weakly exogenous or which did not respond to shocks initiated in the system. Such markets are preferable places to intervene since every change most of the time is related to change in long run market clearing price not to short term random shocks. In estimation of adjustment parameters given there is ARCH/GARCH effect observed in some markets robust standard errors are used to control the problem to same extent. As can be seen in table 9 below the deviation from equilibrium in long run relationship between Addis Ababa and Shashemene is not adjusted in Shashemene, which is observed to be weakly exogenous to any shock emanating from all cointegration relations. However when shocks are emanating form Shashemene all markets but Gonder are reacting in the wrong direction to amplify the shock than to eliminate it as expected in cointegrated network of markets. Moreover when there is shock between Addis Ababa and Bale Robe it is also observed to be amplified in Addis Ababa. So the central market of Addis Ababa is amplifying if shocks are initiated in surplus markets and when the surplus market is Shashemene most markets are going to confusion and disarray.

Table 9 Adjustment parameters in rule of one price which include Addis Ababa and other 4 markets

	Cointegrated market with Addis Ababa under 5 th dimension				LM test for over all significance (df-4)	
	Shashemene	Jimma	Bale Robe	Gonder	Statistics	Prob.
Shashemene	-0.091	-0.016	0.055	0	1.25	0.8697
Jimma	0.4***	-0.468***	0.033	-0.142	27.69	0
Bale Robe	0.35*	-0.065	-0.197*	0.107	10.89	0.0278
Gonder	0.161	0.018	0.004	-0.333***	18.57	0.0010
Addis Ababa	0.284**	-0.043	0.131*	-0.048	21.77	0.0002

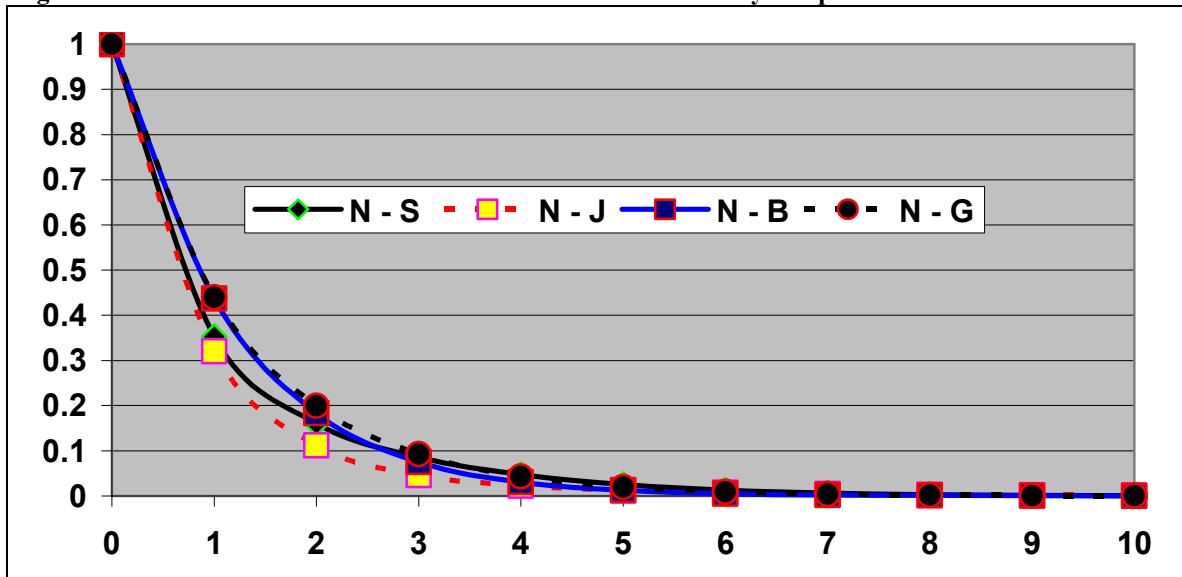
Note 11***, ** and * imply significance at 1%, 5% and 10% level, respectively.

Again the strongest cointegration between Jimma and Addis Ababa is also backed by adjustment parameter which is showing that it will take in Jimma and Addis Ababa close to two months or 2.14 month to be precise to correct shock initiated in long run cointegration relation between Jimma and Addis Ababa. The relative figure for Bale Robe is 5 months and is not significant at 5% but 10% level. For Gonder it will take 3 months to correct shocks initiated in the long run relationship between Addis Ababa and Gonder. So in general the customer centers of Jimma and Gonder have better information flow with Addis Ababa than surplus markets of Shashemene and Bale Robe. The market seems to face confusion when shocks are initiated in surplus markets than deficit markets. Additionally unlike persistence profile transportation convinces did not seem to be a critical factor for quick adjustment of shocks initiated in given cointegration equation.

3.5.2. Market combinations which include Nazret

The short run dynamics in Nazret's cointegration with the four markets, that is Jimma and Gonder as deficit markets and Shashemene and Bale Robe as surplus markets is analyzed and presented below. For presentation convince Nazret is chosen as normalizing variable given its importance in both export and import market so it could be taken as secondary central market. In this combination the strongest cointegration is observed first between Nazret and Jimma followed by Nazret and Shashemene (see figure 6 below). Moreover Gonder and Bale Robe again are having the weakest cointegration in the rule of one price.

Figure 6 Persistence between Nazret and other 4 markets ruled by one price



note 12 B –Bale Robe, G –Gonder, J – Jimma, N-Nazret and S- Shashemene

In both Jimma's and Shashimiene's cointegration with Nazret when a system wide shock is injected to these markets most of it is corrected on average of 18 and 25 days, respectively (see table 10, below). But the relative figure for Bale Robe is 22 days and for Gonder is 25 days. One interesting point about Shashemene is that even though 65% of the system wide is shock is corrected in first month on average it is observed to take 25 days to eliminate its impact. Means the remaining shocks are having long memory and will take time before their impact can be eliminated. This is consistent with ARCH/GARCH effect observed in Shashemene. Which also implies that since shocks are clustered stabilization of price if targeted in Shashemene will be very costly and very complicated.

Table 10 Persistence between Nazret and other 4 markets ruled by one price

Market combination	N – S	N – J	N – B	N – G
Mean persistence in months	0.835542	0.615152	0.730741	0.831335
Mean persistence in days	25.06626	18.45456	21.92223	24.94005
First month Persistence (%)	0.353012	0.320257	0.437202	0.440079

note 13 B –Bale Robe, G –Gonder, J – Jimma, N-Nazret and S- Shashemene

For Jimma the first month correction is 67% but for both Bale Robe and Gonder the relative figure is 56%. So in one month both Jimma and Shashemene are correcting significant slice of a system wide shock. But then after the correction process is very sluggish in Shashemene. Bale Robe and Gonder are having the higher persistence compared to Jimma at all lags and to Shashemene at first month. One important point to note is that given Nazret is found with in 100 km from Addis Ababa and the markets which are having strong cointegration are the same as the markets found in first combination implies that there is positive association between transportation convince and strength of cointegration. This is based on the assumption that low persistence is indirect measure of strength of cointegration as assumed by Gonzalez – Rivera and Helfand (2001). But as was stated before, these shocks are corrected in the system of one price possibly by all market not by a single market. So which market is correcting which shock is an important question that needs a clear answer. Now let's focus on adjustment parameters to measure the other side of the short run dynamics.

Table 11 Adjustment parameters in rule of one price which include Nazret and other 4 markets

Markets	Cointegrated market with Shashemene under 5 th dimension				LM test for over all significance (df-4)	
	Shashemene	Jimma	Bale Robe	Gonder	Statistics	Prob.
Shashemene	-0.189	-0.025	-0.009	0.026	4.63	0.3274
Jimma	0.431***	-0.458***	0.058	-0.151	27.77	0
Bale Robe	0.348*	-0.089	-0.198	0.105	10.12	0.0384
Gonder	0.106	0.008	-0.033	-0.319***	19.85	0.0005
Nazret	0.222	-0.042	0.149	-0.039	10.67	0.0305

Note 14***, ** and * imply significance at 1%, 5% and 10% level, respectively.

And table 11 above shows that Shashemene is weakly exogenous even in this group. This is so since it is not correcting any deviations from equilibrium resulting in all cointegration equations. Moreover Jimma and to some extent Bale Robe are observed to amplify any disequilibrium resulting on the cointegration relation between secondary market of Nazret and Shashemene. Jimma and Gonder did correct any deviation from equilibrium in their long run equilibrium with Nazret in 2nd and 3rd months, respectively. As before strong correction of shocks is observed in deficit market of Jimma followed by another deficit market of Gonder. Both surplus centers of Shashemene and Bale Robe are not correcting deviations or shocks on their long run relationship with Nazret.

In terms of weak exogenous-ness only Shashemene is clearly weakly exogenous since the null of weak exogenous can't be rejected at 32% level. For others the null is rejected at 5% level and mainly for Jimma and Gonder it is rejected at 1% level.

A general reflection about distance and its impact is that, first being part of the common trend is not solely determined by distance though it may be one of the many important factors. However if markets are under rule of one price and shocks are initiated in deficit market, they can be easily processed by each market than shocks coming from surplus market. However system wide shocks are more quickly corrected in those markets which are located in small distance from central market and which are connected with central market with good quality roads.

3.6. Implication for price stabilization

Out of 8 markets considered in the study 7 are observed to have some form of cointegration with few or all markets, assuming there is no trend in transaction cost data. The exception being Mekelle located in North drought prone area of the country. However if trended transaction cost is allowed it was observed that even Mekelle is also having cointegration with important markets like Addis Ababa, Jimma and Bale Robe (see the working paper version of the paper in Taddese 2009). So prices in Ethiopia wheat markets are clearly cointegrated to one another in sense that any change in market price will be felt in other markets some way or another. However the cointegrations are observed to be perfect only in 6 markets which are following rule of one price. These markets include two central markets of Nazret and Addis Ababa, two surplus markets of Shashimiene and Bale Robe and two deficit centers of Gonder and Jimma. The two markets excluded from the rule of one price are Mekelle which is food deficit market in north and another food deficit market in East that is Dire Dawa. Both markets have large food aid dependent population and food aid have been blamed for distorting prices by some researchers (Jayne and Daniel 1995, Wolday et al 1997). So even though it need farther research it is possible both markets are found not to be part of the one price system because the impact of food aid. This conclusion will farther make sense if we consider the fact that the two deficit markets which are part of the one price system are Gonder and Jimma. Gonder is located in high potential area in North West and Jimma is populated by Chat and coffee producing small scale farmers. The population living in both has better purchasing power compared to population living in Mekelle and Dire Dawa.

With in the 6 markets ruled by one price, market clearing price seems to be discovered mainly in two surplus markets of Bale Robe and Shashimiene and one deficit market of Jimma. Jimma is observed to have lesser but significant impact on price fixation compared to both Bale Robe and Shashimiene. However any shock initiated in both surplus markets of Bale Robe and Shashimiene seem to take the system in to confusion and disarray before it gets sorted out in the system. Means the market can handle better shocks coming from deficit markets than surplus markets. And this is logical given low urbanization and slowly growing per capital income observed at that time with very erratic 5 -10 years cycle of drought. Moreover Shashemene is observed to be weakly exogenous to other markets but it is also observed to have volatility cluster problem. Persistence of shocks is higher in Bale Robe followed by Shashimiene and Jimma, respectively.

So the logical policy implication is that if the focus is in long run effective price stabilization the intervention should be in the two surplus markets Bale Robe and Shashimiene. But the national market may go in to disarray in the short run. But most importantly it may not be politically feasible to dump grain in surplus markets. The other option is to dump grains in deficit market of Jimma and by crowding out demand generated from export revenue by small scale farmers it is possible to stabilize the market. The additional advantage is that Jimma's market has less persistence of shocks and did not have volatility cluster problem. Volatility cluster can make intervention very

risky and costly, since shocks will come in cluster. However there are two problems to intervention that can be done in Jimma. First the market is not weakly exogenous means its price are not determined by local dynamics only but by over all national dynamics. So there is need for national wide assessment before any intervention can be effectively implemented. Means there is need to assess trade pattern, price and production among others in all important markets of the country. But in age of the internet this may not be a hard business to handle. The second problem is that intervening in Jimma is in sense like giving subsidy to the better off farmers and it can raise equity issue. So there is need to complement it in food deficit markets without effective demand by distribution of food aid or lower priced grains. This is needed for equity and political feasibility but not for efficiency reasons since producer centers and Jimma, only, are observed to fix white wheat whole sale price. Means if there is pamper harvest price will be lower and when there is drought price will sky rocket. So intervening in deficit markets except Jimma may be needed for equity purpose but not for efficiency purpose.

This fact may also explain why the current policy of price stabilization by providing subsidized white wheat to the poor fail to reverse the trend of inflation than to stop it's up climb. An important point is that the data used in this paper is collected from 1996 to 2003. The assumption is that the grain market structure is not altered then after. So any one who assumes that the structure is significantly altered have logical ground to doubt the conclusion and possibly make analysis on current prices. The basic assumption in this paper is first the market structure and conduct is not altered between 2003 and 2008. However holding this assumptions and the result of the paper it would not possible to expect such unprecedented increase in price level when there is pamper harvest reported. So the result should not be taken at its face value but as base line. And there is need for farther research on current prices. Such research can shade light in the causes of current inflation. If customer centers start to dominate the common trend it would imply inflation is caused by economic growth, increase in per capital income or export orientation of small scale farmers. If central markets become very dominant it could imply change in market structure and conduct. However if the current result holds there is a need for reassessing the way production data is complied to make it more robust.

4. Conclusion

The three important conclusions are: first considering efficiency of stabilization, equity and political feasibility it seems very logical first to focus in deficit markets with real purchasing power for price stabilization purpose and for both political feasibility and equity purpose to supplement it by distribution of food aid and subsidized grains for those below poverty line.

Second distance although is not the critical factor for inclusion of markets under rule of one price, once markets are under rule of one price their relative strength of cointegration is found to be highly associated with level of transportation convenience (road quality and distance). The implication is that in economy with less developed markets, market failures and the institutional solutions adopted to deal with them may have more important role to play in determining the order of inclusion in to rule of one price than

transportation convince per se. So the finding in more developed rice market of Brazil by Gonz'alez-Rivera and Helfand (2001) that distance is main determinant of the border of rule of one price may not work in less developed market like Ethiopia. Means distance is important but is not the only critical factor. However once the markets are under the rule of one price those with lower distance from central market and with better quality roads are observed to have stronger cointegration with others in the system.

The last conclusion is related to the fact that the search procedure used by Gonz'alez-Rivera and Helfand (2001) and adopted by Rashid (2004) though theoretically unsound it is observed to work for Ethiopian grain markets. The tedious search for the markets under rule of one price used in this paper generated the same markets that can be found if we follow their simple search methodology. The question is does it work always or these are special cases? This needs farther research since lower dimension estimation of higher dimension systems will normally introduce omitted variables bias (Gonz'alez-Rivera and Helfand 2001). Means the procedure is theoretically unsound.

Appendix 1
Test for ARCH/GARCH effect

Table 12 Test for ARCH (p+q) or GARCH (p, q) effect

Combination (lags)	markets	Wald test		
		Wald statistics	Degree of Freedom/ lags used in artificial regression	Probability
J – A (1)	J	0.07	1	0.7954
	A	0.21	1	0.6479
B- A(1)	B	0.04	1	0.8400
	A	0.21	1	0.6460
D- B(1)	D	49.18	5	0.0000
	B	0.13	1	0.7167
J–A–B(1)	J	0.33	1	0.5678
	A	0.11	1	0.7455
	B	0.05	1	0.8147
J–D–B (1)	J	0.04	1	0.8375
	D	0.12	1	0.7302
	B	0.06	1	0.8063
J–D–B (7)	J	0.17	1	0.6839
	D	55.06	5	0
	B	0.49	1	0.4837
A-B-G-J(1)	A	0.09	1	0.7591
	B	0.06	1	0.8027
	G	1.11	1	0.2918
	J	0.76	1	0.3819
B-G-J-N(1)	B	0.02	1	0.8810
	G	1.55	1	0.2127
	J	0.78	1	0.3756
	N	0.08	1	0.7834
B-J-N-S-G(1)	B	0.17	1	0.6820
	J	1.01	1	0.3153
	N	0.16	1	0.6896
	S	61.22	2	0.0000
	G	2.78	1	0.0954
G-B-J-A-S(1)	G	2.76	1	0.0964
	B	0.12	1	0.7250
	J	1.06	1	0.3023
	A	0.04	1	0.8468
	S	39.14	2	0.0000

note 15 A – Addis Ababa, B –Bale Robe, D – Dire Dawa, G –Gonder, J – Jimma, N-Nazret and S-Shashemene

Appendix 2
Highest serial correlation and serial lag selected by information criteria for combinations with some evidence of serial correlation

Table 13 Farther evidence on serial correlation

Markets	LM statistics	Serial lags	Degree of freedom	Probability
The lag with highest serial correlation				
J-D-B	13.2358	1	9	0.152224
A-B-G-J	176.9931	9	144	0.032056
B-G-J-N	151.6272	8	128	0.075558
B-J-N-S-G	233.433	9	225	0.335779
G-B-J-A-S	247.9333	9	225	0.140613
The lag selected by information criteria				
A-B-G-J	20.2859	1	16	0.20762
B-G-J-N	19.0032	1	16	0.26850

note 16 A – Addis Ababa, B –Bale Robe, D – Dire Dawa, G –Gonder, J – Jimma, N-Nazret and S-Shashemene

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