SPATIAL PRICE DYNAMICS AND PRICING CONDUCT OF WHEAT MARKETS IN ETHIOPIA[1]

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Abstract

This paper has examined the spatial integration, price dynamics, and pricing behavior of wheat markets in Ethiopia using 72 months retail price series (July 2001-June 2007) and cross-section data of structural determinants of spatial integration. Dynamic measures of spatial integration including long-run multipliers, speed of spatial price adjustment, and composite index were estimated to measure the magnitude, speed, and extent of spatial linkages and to identify the relative importance and pricing conduct in these markets. The common assertion that Addis Ababa is a central market dictating commodity price formation process in Ethiopia was disproved. Nazreth wheat market was found to be the center of price discovery in the country by dictating price formation in supply markets. The three hypothesized oligopolistic pricing behavior of wheat markets— spatial price discrimination, instantaneous and cooperative pricing, and perfect price matching — were tested. The two hypotheses that wheat markets exercise spatial price discrimination and cooperative pricing were rejected. However, the hypothesis of spatial price discrimination was accepted for some markets trading with Addis Ababa and Nazreth. This is verified to be the result of price discrimination exercised in Addis Ababa and the response of supply markets against the conduct in the

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destination markets. Supply markets with alternative market outlets were trying to establish short-run market independence depending on the pricing conduct prevalent in the destination markets while those without alternative market outlets were victims of the pricing behavior. This is an indication of inefficient pricing system prevalent in the wheat marketing system. Structural determinants of spatial market integration including inter-market road distance, road density, dissimilarity in per capita wheat production, and dissimilarity in population density were estimated and tested for their possible effect on the level, speed and extent of market integration to identify alternative market development interventions. Except for population density, all the selected factors of market integration were found to significantly determine market integration in Ethiopia. The spatial integration of Ethiopian wheat markets was found to be generally low in magnitude and sluggish in speed because of lack of flexibility and responsiveness of the marketing system.

Key words: Price dynamics, long-run multiplier, speed of adjustment, composite index, pricing behavior.

1. Introduction

A priori economic theory indicates that spatially efficient markets increase supply and decrease price of goods and services in deficit areas, and decrease supply and increase price of goods and services in surplus areas. This increases the benefit of both producers in surplus areas and consumers in deficit areas to generate a positive net effect on social welfare which is a very important social function of spatial arbitrage (Tschirley, 1995). Moreover, prices in efficient markets are relatively stable and they can be forecasted. Periodic gluts and shortages are indicative of spatial inefficiency of markets.

The Ethiopian wheat production is not evenly distributed geographically. According to the survey conducted by Central Statistical Agency (CSA), about 95% of the national wheat production is produced in the regional states of Oromia, Amhara, and Southern Nations Nationalities and Peoples State (SNNPS). Most parts of the localities in the country are supplied through spatial arbitrage from these producing areas. Such distribution of goods can be economical if spatial arbitrage is efficient. Market efficiency is the distribution of goods and services related not only with the market performance but also with the problem of food insecurity. Without efficient spatial arbitrage of food products, food shortage in an area cannot be prevented from causing famine in deficit areas. Spatial food insecurity can be prevented before triggering famine if spatial arbitrage is efficient to distribute produces from surplus areas to deficit areas (Webb *et al.,* 1992).

Efficient markets are integrated spatially, temporally and vertically across different forms of products. The critical importance of spatial arbitrage calls for the need to know the extent of spatial market integration, pricing conduct and adequacy of marketing infrastructural facilities. This enables to fix intervention measures for a better market performance and prevention of food shortages in deficit areas. There is no clear and sufficient understanding about the strength and speed of spatial market integration and price dynamics in Ethiopian wheat markets. Ethiopian wheat markets are alleged to be inefficient by various marketing agents such as producers, consumers, grain traders, and the government.

For the majority of grain markets, the dynamics of spatial price adjustment is not estimated to enable cost-effective policy intervention and evaluation of policy effects. Most spatial market integration studies are conducted to estimate cointegration coefficients as measures of the long-run integration of markets. However, cointegration coefficients cannot indicate the actual magnitude and speed of price adjustment, and direction of price causation. The other major problem of spatial market integration studies conducted in Ethiopia is the selection method. Less objective criteria are used to specify the price interdependence between markets so that the models will be miss-specified either by omission of major markets or inclusion of less important markets. This leads to erroneous conclusions. However, there are some impacting studies conducted on the Ethiopian commodity marketing system after liberalization of the marketing system in Ethiopia which enabled to generate some relevant policy intervention measures in the country. The most important initiative was the Grain Market Research Project (GMRP) conducted just after liberalization of the markets which resulted in production of a number of working papers on grain markets including Asfaw and Jayne (1997) and Gebremeskel et al (1998). The latest studies assumed to have significant policy and intervention impact include the papers by Eleni (2001), Kindie (2007), and Kindie *et al* (2006). Because of these limited research efforts, there is still a wider gap to fill the requirement for sufficient empirical evidence on the Ethiopian grain marketing system. There are many markets and commodities not yet addressed properly. Generally, there is lack of sufficient, latest, accurate, reliable, and prompt information about the efficiency of arbitrage in the discovery of wheat prices across markets in Ethiopia. Among other things, the Ethiopian wheat marketing system has problems requiring empirical justification on the extent of price dynamics, pricing conduct, and major factors determining market integration covering major markets and commodities. Accordingly, this study is conducted to generate information and fill some gaps in the price adjustment dynamics, the pricing behavior, and the structural determinants affecting the price adjustment process in wheat markets.

The specific objectives of the study are:

a. to estimate the magnitude, speed and direction of spatial price dynamics of important wheat markets;
b. to identify the pricing conduct of wheat markets; and
c. to identify the factors that determine the integration of the markets and to estimate their impacts on the extent of wheat market integration.

The remaining parts of the paper are organized in four units. The overview of the commodity marketing system in Ethiopia and the research methodology are presented in the second and third units, respectively. Discussion of the results is presented in the fourth unit and the last unit concludes the paper.

2. The Commodity Marketing System in Ethiopia

There have been different studies on commodity market performance conducted in Ethiopia since the commodity market liberalization in 1990. Performance of the marketing system is verified by these studies to suffer from various problems. The most dominant studies are reviewed to highlight the nature of the marketing system, to qualify previous contributions, and to identify the knowledge gap existing in researching the Ethiopian commodity marketing system.

Webb *et al.* (1992) have studied the spatial integration of cereal markets in Ethiopia to detect the spatial efficiency of local markets and their contributions in alleviating food shortage that has occurred because of drought in different geographical locations. The study was conducted in situations of low marketing infrastructure and strictly government controlled trade policy before 1990 (data for 1984-89). That period is expected to be quite different from the 17 years of trade liberalization period. They have used 13 selected regional markets, 3 grain types, and 70 monthly price observations. Most of the markets were found to be segmented from the principal market, (i.e. Nazareth), even within an average distance of 461 kilometers. Few markets were weakly integrated within an average distance of 253 kilometers from the reference market, and the rural markets were almost totally segmented from the respective regional markets. The study used two models of market integration: correlation coefficients and index of market connection (IMC). However, Dercon (1995) has used cointegration technique to analyze market integration in Ethiopia and verified that most market prices were cointegrated with Addis Ababa price, assumed to be the central market.

After grain trade liberalization in Ethiopia, the major breakthrough in grain market efficiency studies are those studies conducted by Grain Market Research Project (GMRP) under the Ministry of Economic Development and Cooperation (MEDAC). This research project has resulted in various working papers and market analysis notes on both input and output markets. Asfaw and Jayne (1997) have analyzed the response of Ethiopian grain markets to market liberalization policy by selecting 11 grain types and eight local markets. Among the eight local markets four of them were wheat markets (one surplus and three deficits). They have used simple price correlation coefficients to estimate the spatial efficiency of these markets using 10 years monthly price data, and 13 months price series to estimate the equilibrium grain prices as a function of seasonality, grain market liberalization policy measures, rainfall, and food aid. The spatial price correlation coefficients for wheat markets were ranging from 8% to 82%. The researchers have concluded that there was spatial efficiency and commented on some of the problems to be resolved for better spatial efficiency. Asfaw and Jayne (1998) again have studied the spatial and the vertical integration of grain markets in Ethiopia. They considered a total of 10 markets (seven surpluses and three deficits) to analyze the spatial wheat price relationships with the Addis Ababa market. In their analysis, they found that grain prices in the seven markets (78%) were not significantly related with that in Addis Ababa market, which is a contradiction with the results of the first study conducted by them a year before. However, the existence of a real and long-run relationships between grain markets was not indicated since the scope and purpose of the study was vast.

Gebremeskel *et al.* (GMRP, 1998) has studied the market structure, conduct, and performance of markets by giving a special emphasis on the constraints of grain markets in Ethiopia. In their analysis using temporal and spatial price relationships of 11 selected grain markets and three grain types, they have identified the major constraints of Ethiopian grain markets. These constraints include *kella* charges between markets, absence of control on un-licensed merchants, absence of access to transportation service, and market information. Even though their study was not designed to identify and estimate the magnitude and speed of spatial market integration, they have indicated that there were problems and constraints in the spatial market integration

Eleni (2001) has studied the marketing institutions, transaction costs, and social capital in the Ethiopian grain market based on 1996 market survey data and coefficients estimated by another study. Among other things, she identified the pricing conduct behind integrated markets and concluded that they seemed spatially efficient without exhibiting price efficiency. This was due to collusive pricing conduct that was prevalent in urban grain markets. However, there were no estimates of long-run market integration to compare the difference between short-run and long-run integration measures, and to conclude about extent of spatial efficiency in Ethiopian grain markets.

Kindie *et al.* (2006) have analyzed the dynamics of six white wheat markets (Nazreth, Shashemenie, Jimma, Addis Ababa, Dire Dawa, and Mekelle) using vector autoregressive (VAR) model assuming the first three to be surplus and the last three to be deficit markets of wheat. They used the VAR model assumed to be better alternative model to address the simultaneous interaction of markets by identifying markets with common factors for policy intervention. They selected these markets assuming that they were major supply and consumer markets. The monthly wholesale price levels were tested for causality using vector error correction mechanism (VECM) in which case Nazreth and Shashemenie were found to be price leaders while there was no exclusive price leadership of wheat markets in the country. The common assertion that Addis Ababa is a price leader was not supported by the results. However, the markets were selected by “their importance as a major supply or as a major consumer market” that there is no justified criterion as to why not other major wheat supply markets were not included. The dominance of a market in the general supply or consumption of goods cannot guarantee its dominance in wheat supply or consumption. This method of market selection might have resulted in misspecification of the price interdependence (ignoring very dominant markets and including insignificant markets of wheat). Generally, this study is relatively more empirical than previous studies conducted in Ethiopia and the weak parameter estimates signify the considerations to be taken in sampling of relevant wheat markets to avoid risk of misspecification of price interdependence.

Kindie (2007) has analyzed the spatial equilibrium of wheat markets in Ethiopia by considering one supply (Ambo) and one central market (Addis Ababa) using autoregressive distributive lag (ARDL) approach to estimate the dynamics of price transmission of white wheat between the two markets. Based on the results of the coefficients of the cointegration analysis, he recommended that it is better to use intervention measures in the central market rather than in local markets since stabilization measures in local markets would result in high cost of intervention. The number of markets considered is limited; in which case the pattern of price interdependence between terminal and surplus markets might be different for other markets. Because of the risk of ignoring other important wheat markets, *i.e.* misspecification, the pattern of price interdependence between Ambo and Addis Ababa might not be taken as common factor for other market pairs and it might be difficult to recommend about the point of intervention required. However, this work was a basis for further studies to address more markets and commodities traded in Ethiopia.

3. Methodology

3.1. Data and Sampling Techniques

The specification of price interdependence between markets is determined by the selection of markets in the spatial analysis. The selection of markets is the selection of both explanatory and dependent variables because we use variables like price information and commodity flows in these markets. If relevant markets are excluded, the results will validate the absence of price interdependence, or less important market will seem dominant. In literature, there is no objective criterion as to how to select all important markets or to exclude all less important markets before estimation. Because of this problem many spatial market integration studies conducted at national level use less objective criteria to select important markets. In the presence of this problem, Asfaw *et al* (1997), Asfaw (1998), Kindie *et al* (2006), and Kindie (2007) have selected their markets of interest by less objective criteria. However, the studies have their useful policy implications on the Ethiopian grain marketing system and are indicative of the caution to be taken in modeling of price interdependence.

In this study, a relatively more objective criterion of market selection was proposed and applied. The criteria of per capita wheat production, annual retail price, and distance from the destination market were used in order to avoid specification errors in selection of supply markets. The sample markets were selected using a multi-stage sampling method. First, supply regional states were selected by their annual per capita wheat production potential. Accordingly, two regional states (Oromia and Amhara) were selected and wheat producing zones in these regions were identified by the same criterion. The supply zones (with their per capita wheat production in kilograms per person per annum) were selected to be Bale (118.2), Arsi (109.2), West Shewa (87.6), North Shewa of Amhara Region (73.2), East Shewa (72.9) South West Shewa, East Wellega (40.2), and South Wello (36.5). The markets in these supply zones were, in turn, selected by their (lowest) annual average retail price of wheat in 2005/06 and their (nearest) distance from the destination market.

The major destination markets were automatically selected as deficit (destination) markets. The price and the distance criteria can avoid the selection of distant markets because of their natural tendency of price decrease as the inter-market distance increases. Based on these criteria, the most surplus eight wheat markets were elected. These markets were Adaba, Diksis, Ambo, Debre Birhan, Nazreth, Woliso, Shambu, and Dessie. The destination markets were Addis Ababa and Mekelle, and the markets pairs were constructed based on the presence of wheat stock flow between markets.

Ethiopian wheat markets have many structural deficiencies, in which case, spatial price adjustment is expected to be very sluggish. Price movements or fluctuations across wheat markets are more frequent and observable on monthly basis, than weekly or daily basis, where markets are weakly integrated. If the price dynamics is expected to be sluggish, even if weekly prices are preferable, monthly prices are also applicable. For instance Mendoza and Rosegrant (1995b), Tschirley (1995), Asfaw and Jayne (1997, 1998), Kherallah *et al* (2000), and Kindie *et al* (2007) have used monthly average prices to estimate spatial market integration measures.

The minimum time required to respond to price changes occurred in another markets is, therefore, expected to be at least a month. Reaction time less than a month is considered to be instantaneous. Moreover, price data are readily available on monthly basis for the selected markets justifying that data availability was the main reason to use monthly retail price-series for the study. Monthly retail prices of six years (July 2001-June 2007) and relevant consumer price indices (CPI) were collected for the selected markets from statistical reports of CSA. 720 monthly average retail prices for 10 markets and 72 consumer price indices for food were collected. Data gaps on prices were highly insignificant (only 2.2%). These price data gaps were filled by the average of the prices in the previous and the following months.

The data required to explain the reasons behind the integration of the markets in this paper include inter-market distance, road density, dissimilarity in per capita wheat production (DPCP), dissimilarity in population density (DPD), and supply shocks. They were collected from primary (field surveys) and secondary sources. The time series annual wheat production data indicated the absence of significant wheat production shocks in the areas of the selected markets.

In this empirical study, the spatial market integration is expressed in terms of price interdependence. Price information flow creates commodity flows directly or indirectly to influence commodity prices across markets. However, measures estimated from nominal prices are expected to be spurious and, hence, prices should be transformed to eliminate these spurious relationships. Variable transformation avoids or minimizes problem of multicollinearity, converts a nonstationary time series into stationary, changes nonlinear relationship into linear, and avoids problem of seasonality and other common macroeconomic factors such as inflation (Tschirley, 1995).

Nominal prices were deflated by the consumer price index (CPI) for food. The weight of white wheat in computing CPI for cereals was high, but its share in computing the general CPI for food was about 4% which is insignificant to affect the deflation (CSA, 2007). Since wheat was the major component to compute CPI for cereals, the appropriate deflator was found to be the CPI for food. To overcome the above estimation problems, monthly real retail price series were transformed to natural logarithms, and the differences of their natural logarithms were multiplied by 100 to avoid scaling problems. The parameters were estimated by percentage real price changes transformed as

$$\Delta P_t = (\ln P_t - \ln P_{t-1}) \times 100 \quad \textbf{(1)}$$

Where $\Delta P_t =$ percentage real price change of white wheat at time t; $P_t =$real retail price of white wheat; $\ln$=natural logarithm; P_{t-1} =lagged value of the real price; and $t =$time in months.

3.2. The Dynamic Model

There are many alternative models of dynamic analysis, which could be applied in market integration studies. But Mendoza and Rosegrant (1995) have proposed a multiple autoregressive commodity model and simplified it to a bivariate autoregressive (BAR) model to represent spatial pricing behavior. This model is recently used in many empirical studies to represent spatial market integration and pricing conduct with slight modifications. For instance Goletti (1994), Goletti and Christina-Tsigas (1995), Mendoza and Rosegrant, (1995a, 1995b), Minot and Goletti, (2000), and Kherallah *et al*. (2000) have used this model to estimate dynamic multipliers. The measure of spatial market integration by dynamic adjustments avoids the limitations of correlation coefficients, Timmer's index, and cointegration coefficients.

The dynamic model employed in the study was the BAR model. The short-run and the long-run estimates are known as dynamic multipliers, interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable. This dynamic analysis was expected to provide more information than the cointegration procedure. Cointegration analysis is an econometric technique that allows the identification of presence of some sort of long-run relationship between markets and its direction, whereas the BAR analysis identifies and quantifies the magnitude and speed of market integration, and detects the direction of causal relationships between prices of markets (Goletti and Christina-Tsigas, 1995).

In the BAR model, the contemporaneous percentage price change in market i is a function of its own historical percentage price changes, and the contemporaneous and historical percentage price changes in market j specified follows;

$$\Delta P_{i,t} = \sum_{K=1}^{K=m_i} \alpha_{i,K} \Delta P_{i,t-k} + \sum_{h=0}^{h=n_i} \beta_{i,h} \Delta P_{j,t-h} + X_{i,t} \gamma_i + \varepsilon_{i,t} \qquad (2)$$

Where $\Delta P_{i,t} =$ Percentage change in monthly real retail price of wheat in market i at time t (months); *i.e.* contemporaneous percentage real price change; $\Delta P_{j,t-h} =$ Percentage change in monthly real retail price of wheat in market j at time $t-h$; *i.e.* lagged percentage real price change; $X_{i,t} =$ Exogenous variable such as seasonal dummies and time trend at time t, (*i.e.* instrumental variable); m_i and $n_i =$ Number of lags in monthly percentage real retail price changes as identified by AIC procedure in market i and j respectively; $t-k =$ Historical percentage real price changes in market i; $t-h =$ Historical percentage real price changes in market j; $\alpha_{i,k} =$ Own lagged price effect; $\beta_{i,h} =$ Contemporaneous price multiplier (if $h=0$), and lagged price multiplier (if $h=1,2,\ldots,n_i$) of market j on market i; $\gamma_{i,t} =$ Coefficient of instrumental variable; i and $j =$ Spatially separated markets, and $i \neq j$; and $\varepsilon_{i,t} =$ Disturbance terms in market i at time t.

3.3. Tests and Specification Procedures

Before estimation of the dynamic measures of integration, the price series and the market pairs were tested for stationarity, cointegration, and causality; and the lag structure was specified.

3.3.1. Tests for Stationarity and Cointegration

To distinguish the presence of a unit root in the percentage price changes of wheat, the Augmented Dickey-Fuller (ADF) test was employed by estimating the following equation (with and without drift) and testing for the corresponding null hypothesis (Dickey and Fuller, 1979):

$$\Delta P_{i,t} = b_0 + \delta \Delta P_{i,t-1} + \sum b_i \Delta P_{i,t-k} + u_t \quad (3)$$

$$H_0 : \text{Percentage price change in market } i \text{ has a unit root.}$$

Where u_t is the random term and $b_0, \delta, \text{and} b_i$ are coefficients to be estimated and tested.

The stationarity of the residuals from the individual time series is not sufficient to avoid spurious regressions. The

To check whether or not two markets were linearly cointegrated in the long run, the Engle-Granger (EG) two-step procedure was employed (Engle and Granger, 1987). If the linear combination of all the variables in (2) is tested for cointegration, the regression will not be spurious and this indicates that the linear autoregressive model represents the long-run price interdependence between markets. Accordingly, the BAR model indicated in equation (2) was estimated and the residuals from the estimation saved and tested for the presence of cointegration.

3.3.2 Lag Identification

Based on the monthly percentage price changes, the lag structure was identified using Akaike Information Criterion (AIC). The AIC procedure is one of the information based criterion most commonly used in econometrics, which suggests the choice of minimum number of explanatory variables to minimize the objective function that trades off parsimony against reduction in sum of squares (Akaike, 1969). In this case the AIC procedure was used to identify the lag length in months, and the number of lagged terms to be included in the model. The lag structure was identified by estimating equation (2) at chosen number of lags and then by selecting the lag length and number of lagged terms by AIC statistics. This selection was conducted by the residuals obtained and the parameters estimated in (2). For simplicity, the explanatory variables in the model were assumed to have linear combination and finally validated by AIC statistics, adjusted R^2 and F value.

The lag identification procedure avoids the problem of the use of uniform lag length. The lag length of the two variables in (2), one for percentage price changes in markets i and one for percentage price change in market j, was simultaneously estimated by the following objective function;

$$AIC_{ij} = \ln \hat{\delta}^2_{ij} + \frac{2q}{N}; \qquad (4)$$

Where AIC_{ij} = the AIC statistic between prices of markets i and j; $\hat{\delta}^2_{ij}$ = estimated sample variance of the regression in equation (2); N =sample size of the time period; and q =number of explanatory variables in the model including the intercept.

Since both prices in market i and j respond to the same type of shock occurred in other markets, the problem of simultaneity is expected and that the error terms will be correlated with prices in market j. To overcome the problem of simultaneity, an instrumental variables estimation of $\Delta P_{j,t}$ was used, taking lagged values of the prices of all markets included in the study (Goletti and Christina-Tsigas, 1995). The two lags were determined simultaneously; but, zero lags of the instrumental variables were uniformly used.

3.3.3. Causality Tests

Granger causality test was used to establish the existence of a central market (Granger, 1969). Unlike the expected commodity flows, the test for information flow was conducted in both directions for all selected market pairs. This is important because more than one mode of price formations could coexist in a marketing system. Prices could be formed by both the reference and the local markets, because local markets could form prices based on the price formed in the reference market. Local markets could fix prices in collusion or cooperative way (Palaskas and Harris-White, 1993). This real situation calls for the need to analyze the impact of price shocks in both directions.

To conduct the test for causality, the market pairs of market i and j in (2) were considered. The effect of contemporaneous and lagged price changes in market j on contemporaneous price changes in market i were analyzed separately by estimating the restricted regression and the residuals were compared with the results of the unrestricted regression in (2). The test was conducted based on the residuals of the following restricted regression and the corresponding hypothesis;

$$\Delta P_{i,t} = \sum_{h=o}^{h=n_i} \beta_{i,h} \Delta P_{j,t-h} + X_{i,t-h} + e_{i,t} \; ; \qquad \textbf{(5)}$$

$H_o : \beta_{i,h} = 0;\ h = 0,1,2,..., \ n_i$; Independent.

The residual sum of squares obtained from the two regressions was used to test the existence of causal relationship between market pairs. Based on this idea, markets were tested for their unidirectional, bilateral (interdependent), or independent (segmented) relationships by the following F-statistic;

$$F = \frac{(R^2_{ur} - R^2_r)/m}{(1 - R^2_{ur})/(N-k)} \qquad \textbf{(6)}$$

Where R_{ur}^2 = unadjusted coefficient of determination for unrestricted regression; R_r^2 =unadjusted coefficient of determination for restricted regression; k = number of parameters estimated in the unrestricted regression; m = number of linear restrictions (explanatory variables omitted in the restricted regression); and N = sample size in the unrestricted regression.

The causality test was used to identify the direction of causal relationship between pairs of 10 markets. This requires considering 10 bivariate autoregressive equations (20 market pairs), but estimation for price flows was conducted in both directions of the market pairs, each with residuals to be estimated and tested for the 20 equations. This test enables to select market pairs with significant causal relationships and identification of the major markets.

3.4. Estimation

The dynamic measure of integration including dynamic multipliers, speed of price adjustment, and composite index were estimated to measure the magnitude, speed, and extent of integration.

3.4.1. Dynamic Multipliers

Equation (2) is a reduced form representation of price changes as a function of historical price changes in one market and those in the other markets. Estimation is, therefore, possible as the problem of simultaneity is eliminated (Kherallah *et al.,* 2000, Mendoza and Rosegrant, 1995a, 1995b; Goletti and Christina-Tsigas, 1995). The first task in the estimation stage was to estimate the mean value of the regression (2) based on the identified lag structure. This estimation of the mean value enables to detect the average impact of contemporaneous and lagged price changes.

The dynamic multipliers represent quantified percentage of price transmission. They could be short-run; interim; or long run. Short-run dynamic multipliers give the change in the mean value of the dependent variable following a unit change in the explanatory variable in the same time period. If the change in the explanatory variable is maintained at the same level thereafter, then, the sum of the partial coefficients gives the change in the mean value of the dependent variable in the next period. The sum of the coefficients in the second period gives the change after the second period, and so on. These partial sums are the interim dynamic multipliers, and the computation procedure continues up to k periods, until the intermediate multipliers converge to a steady state. The long-run dynamic multiplier is reached at the regression including the k^{th} lag. It is the sum of the impact multipliers of the regression at the maximum lagged variable estimation.

Market pairs with contemporaneous responses have instantaneous responses and hence long-run dynamic multipliers are not computed. Long-run dynamic multipliers are computed for market pairs with lagged responses. The dynamics of the adjustment process involves a series of interim multipliers. If nonzero lags are estimated, the price shock in a market will take time to affect the price change in the other market. It also takes time to complete the price adjustment process caused by the shock. Hence, based on equation (2), the immediate impacts, or the short-run multipliers, are given by the coefficients, $\beta_{i,0}$ (since h = 0). The cumulative effect of an exogenous shock to changes in the retail prices of wheat in market j on the changes in retail prices of wheat in market i after k periods was calculated as

$$\lambda_{ij}^{k} = \sum_{h=0}^{k} \frac{\partial E(\Delta(_{i,(t)})}{\partial \Delta P_{j,(t-h)}} \quad \textbf{(7)}$$

Where λ_{ij}^{k} = Average dynamic interim multiplier after k periods; E = expectation operator based on the price data at time t; k = periods of adjustment in months; h = lag length ($h = 0,1,2,...k$); and ∂ is partial derivative operator.

The dynamic multipliers in equation (8) were computed after each lag period to get the cumulative effect at the end of that period. As mentioned above, the adjustment process takes time, and the full adjustment of the dynamic process in equation (7) is given by the limit of the sequence as follows;

$$\lambda_{ij} = \lim_{k \to \infty} \lambda_{ij}^{k} \quad (8)$$

Where λ_{ij} =Long-run dynamic multiplier after k periods; and ∞ = infinity.

The order of the autoregressive process in the EG test is expected to estimate the length of time it takes for markets to attain full adjustment. It is estimated by the AIC procedure though the speed of adjustment between markets identified by the AIC is parsimonious. This method is also applied, with slight modifications, in empirical studies by, for instance, Goletti (1994), Goletti and Christina-Tsigas (1995), Minot and Goletti (2000), and Kherallah *et al*. (2000). Hence, the speed of spatial price adjustment indicates the extent of market integration between markets in sense that markets with speedy price adjustment are more integrated, and those with sluggish price adjustment are less integrated.

3.4.2 Composite Index

The speed of price adjustment estimates the length of time required to react to price changes occurred in other markets. The combination of magnitude and speed of price adjustment generates another actual measure of market integration, denoted by:

$$\mu_{ij} = \frac{\lambda_{ij}}{k_{ij}} \quad (9)$$

Where μ_{ij} =Composite measure ($0 \leq \mu_{ij} \leq 1$);

k_{ij} =Speed of adjustment in months between market i and j.

This measure has two advantages over the other measures of market integration. First, it combines the information of two measures into one, and second it can rank the market integration across different markets in a country or across countries. The Value of μ_{ij} closer to one indicates more integration of markets and the value closer to zero indicates less integration of markets (Goletti and Christina-Tsigas, 1995). A market with more magnitude and shorter reaction time has higher spatial integration and integration of all selected markets was ranked using this index.

3.5. Pricing Conduct

Markets could be highly integrated in inefficient markets or could be segmented by deliberate action of marketing agents. This is because, short-run integration may be generated by collusive pricing (Mendoza and Rosegrant, 1995a, 1995b). According to the structure-conduct-performance approach of market analysis, efficiency is determined by structure, conduct, and performance of a market. Market conduct refers to the pattern of commercial behavior arising from market structure. Market conduct includes pricing conduct (predatory, exclusionary, collusive, or competitive), product strategy, responsiveness to change, research and innovation, and advertising. Markets may be perfectly competitive; monopolistic; or oligopolistic (Mendoza and Rosegrant, 1995; Pomeroy and Trinidad, 1995; Tilburg and Lutz, 1995). Commodity markets in developing countries are assumed to be oligopolistic.

Oligopoly is said to exist when more than one seller is in the market but when the number is not large to make the contribution of each negligible. A typical oligopoly exists when for example, three firms control over 50% of all sales of a particular good in a particular market and certain barriers prevent potential competitors from entering the market (Pomeroy and Trinidad, 1995). Oligopolistic markets are characterized by 3 pricing behavior: price discrimination, organized pricing, or price matching with offsetting lags.

Economic theory states that prices in competitive markets are determined by supply and demand conditions. If spatially separated markets with low marketing infrastructure fix prices competitively, supply and demand conditions cannot be adjusted instantaneously. But if markets set prices noncompetitively, spatial markets, even those with low marketing infrastructure, will be highly integrated instantaneously by organized action of marketing agents.

Ethiopian wheat markets are suspected for noncompetitive price setting behavior. On a given day, brokers determine up to 11 prices for wheat (and 40 prices for principal grains) traded in Addis Ababa. “The grain market structure does not have a role for market makers who openly purchase unmatched orders at a discount and sell unmatched orders at a premium in order to pay the price of immediacy There is an implicit rule governing the brokers” (Eleni, 2001). A high degree of price integration among markets does not necessarily imply that the market system is functioning properly (Tilburg and Lutz, 1995). Hence, spatial market integration analysis should be complemented with analysis of pricing behavior to conclude about spatial efficiency. If a marketing system is allocatively efficient, consumer preferences are transferred without distortion to producers who will use the price information to make production decisions which are allocatively efficient (Harris-White, 1995).

In this study, the pricing behavior of traders was assessed to detect whether it is characterized by conducts like spatial price discrimination, collusion, price leadership, or competition. The average partial impacts estimated from equation (2) were used to test the pricing conduct of all the selected markets. The dynamic model in equation (2) captures the dynamic price relationship and provides a direct and explicit testing of pricing conduct. A market could be affected by both contemporaneous and historical price changes in other markets. These effects were separately treated and analyzed to identify the pricing conduct in each market. Accordingly, the assumed imperfect wheat markets in Ethiopia were tested for the following 3 hypotheses of oligopolistic pricing conduct;

Hypothesis I: Spatial price discrimination, or market independence;

$$H_o^1 : \beta_{i,h} = 0; h = 0,1,2,..., n_i . \qquad \textbf{(10)}$$

Hypotheses II: Collusive pricing or perfect cooperative pricing;

$$H_o^2 : \beta_{i,0} = 1; \text{and } \alpha_{i,k} = \beta_{i,h} = 0; k = 1,2,... m_i \qquad \textbf{(11)}$$

Hypotheses III: Price matching with delayed responses and offsetting lags;

$$H_o^3 : \beta_{i,0} = 1, \text{ and } \sum_{k=1}^{k=m_i} \alpha_{i,k} + \sum_{h=1}^{h=n_i} \beta_{i,h} = 0. \qquad \textbf{(12)}$$

The first hypothesis refers to the situation when price changes in market j do not affect price changes in market i. Hypothesis II indicates an organized collusive pricing system of instantaneous price arrangements between marketing agents in two spatial markets. The last hypothesis postulates an unorganized market in a base point pricing system based on reference markets that indicates a price leadership system. If all the three hypotheses are false, a non-cooperative form of pricing arrangement is said to exist and the pricing system could be considered as competitive (Mendoza and Rosegrant, 1995a), and markets are actually integrated in an efficient pricing system. These tests validate the existence of real long run price relationships among markets and identifies whether the pricing behavior is competitive or noncompetitive.

3.6. Determinants of Spatial Integration

The effect that structural factors have on market integration explains why markets are integrated. Market integration analysis without the identification of the determinants of integration does not indicate the appropriate intervention measures to be taken for improvement. Developed structural factors that determine market integration are expected to be associated with well-integrated markets while weak market integration is the result of structural deficiencies. Analysis of market integration measures alone is not sufficient to recommend on requirements of market improvement strategies.

The comparison of various measures as well as analysis of the structural factors affecting these measures of market integration is necessary in two sets of issues. First, it gives the concept and measurement of market integration to interpret, to measure, to translate into operational concept, and to identify the relation of each measure and the insights to be derived. Second, the type and extent of the relationship between market integration and structural factors can be identified and estimated (Goletti, 1994).

The strength of market integration and the speed of spatial price adjustment are expected to be determined by the structural factors of market integration including road distance, marketing infrastructure, dissimilarity in production (market volumes), industry concentration ratio, market types (urban and rural), price stabilization policy, and other supply shocks (Goodwin and Schroeder, 1991; Palaskas and Harris-White, 1994; Goletti and Christina-Tsigas, 1995; Kherallah *et al*, 2000). In the Ethiopian context, the expected effects of selected factors on the measures of market integration were hypothesized as summarized in Table 1.

Table 1: Structural factors of spatial market integration and their expected effects

Explanatory variable	Unit of measurement	Expected coefficient
Inter-market road distance	Road distance between two markets (kilometers).	Negative
Road density	Total distance of all weather roads in the surrounding area of two markets (kilometers) per total surrounding area of the two markets (thousand square kilometers)	Positive
Dissimilarity in per capita production (DPCP)	Absolute value of the difference in wheat production per capita per year(kilograms per capita per year)	Positive
Dissimilarity in population density (DPD)	Absolute value of the difference in population density (inhabitants per square kilometer).	Positive
Production shocks*	Number of wheat production shocks in the surrounding area of the two markets.	Negative

*: There was no wheat production shocks observed in the study period.

Based on the above a priori relationships of the structural factors with market integration measures, the most determinant structural factors were identified. The models for all market integration measures were specified using the AIC procedure first by assuming two alternative models with higher coefficient of determination, linear and linear-logarithmic (Lin-Log), each with 3 and 4 structural variables, and then selecting the one which fits best. The functional relationship was identified to be the Lin-Log model for all measures of market integration defined as follows;

$$M_{ij} = \beta_1 \ln D_{ij} + \beta_2 \ln RD_{ij} + \beta_3 \ln DPCP_{ij} + \beta_4 \ln DPD_{ij} + e_{ij} \qquad \textbf{(13)}$$

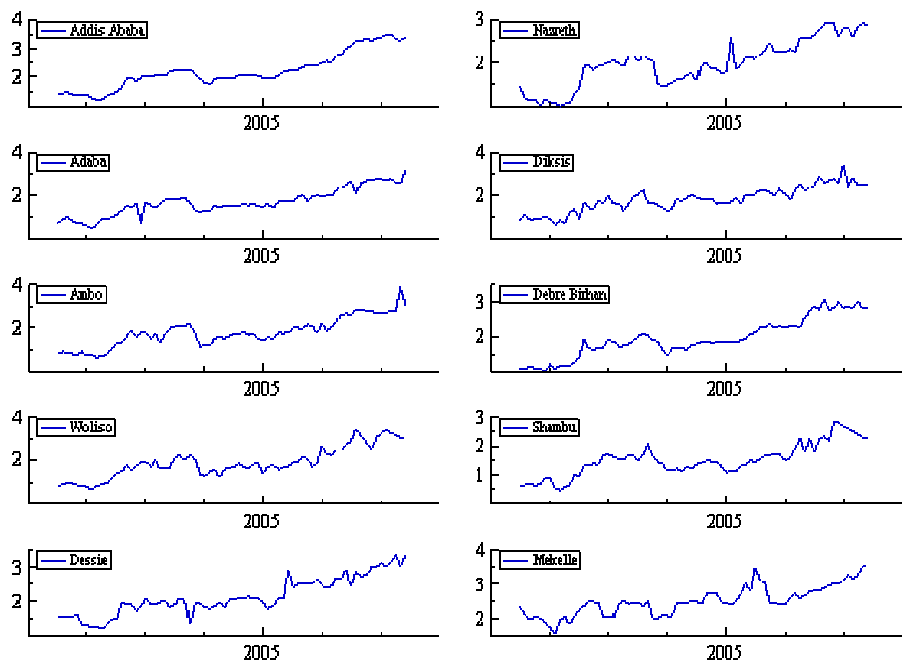
Where M_{ij} =estimated measure of market integration between market i and j; D_{ij} = inter market road distance; RD_{ij} =road density of the area surrounding the two markets; $DPCP_{ij}$ =dissimilarity in wheat production per capita between the two markets; DPD_{ij} =dissimilarity in population density between the markets; ln= natural logarithm, and e_{ij} =disturbance term.

4. Results and Discussion

4.1. Unit Root and Cointegration Tests

Food prices have been drastically developing in Ethiopia's domestic markets since the late 1990s. Price in all markets considered were in general moving together indicating that use of nominal price would lead to spurious regressions because of the nonstationary nature of prices. To detect how spatial prices in supply and destination markets were moving was easily detected by plotting the nominal price series in the 10 markets selected (Figure 1). This pattern has some implications on how wheat prices in different markets were moving together over time and the degree to which prices and spatial margins were instable.

Figure 1: Patterns of wheat prices in Ethiopian major markets (July, 2001-June, 2007)



Source: Plotted from data in CSA, Monthly Statistical Bulletins, various issues.

As the focus of this paper is pattern of price co-movement between spatial markets rather than univariate price analysis, wheat prices were transformed to percentage price changes and these transformed variables were tested for the presence of unit roots. Accordingly, the null hypothesis that the time series of the percentage price changes in a market has a unit root was rejected for all markets at 1% level of the ADF test statistic (Table 2). The monthly percentage price series for each wheat market was individually integrated. This econometric integration of each series was attained by the relevant price transformation which eliminated trends and other variables moving with time.

Table 2: Unit root test results for percentage price changes of wheat in Ethiopian markets (July, 2001-June, 2007).

Percentage price change	Lag length	With drift		Without drift	
		ADF statistics	Critical values (1%)	ADF statistics	Critical values (1%)
Addis Ababa	0	-8.712**	-3.527	-8.768**	-2.598
Nazreth	1	-7.909**	-3.527	-7.964**	-2.598
Adaba	2	-6.315**	-3.530	-6.312**	-2.599
Diksis	1	-8.813**	-3.527	-8.868**	-2.598
Ambo	0	-11.453**	-3.527	-11.481**	-2.598
Debre Birhan	7	-2.761*	-3.538	-2.784**	-2.602
Woliso	1	-8.149**	-3.527	-8.169**	-2.598
Shambu	4	-6.350**	-3.528	-6.262**	-2.598
Dessie	1	-9.505**	-3.527	-9.434**	-2.598
Mekelle	0	-9.124**	-3.527	-9.163**	-2.598

Note: Lag order selection in the unit root testing procedure was routinely informed by Akaike information criterion (AIC) to eliminate the difference in test results expected to be significant if we use different lag specification procedures like Schwarz information criterion (SIC). This is because different procedures have different levels of punishment for new lags to be included into the model. Accordingly, the authors have reported tests only from the AIC procedure to secure uniformity and comparison among all other tests. It is also verified that there is some difference in test results in using a model with or without drift for Debre Birhan percentage price changes. **: Significant at 1% level. *: Significant at 5% level.
Source: Computed from data in CSA, Monthly Statistical Bulletins, various issues.

The econometric integration of individual time series may not lead to the linear cointegration of percentage price changes in the BAR model considered in equation (2). The test for the nonstationarity of the residuals from the bivariate linear combination of these stationary series has resulted in stationary residuals, except for two market pairs, indicating that their linear combination in a bivariate model is cointegrated. The hypothesis that the percentage price changes are cointegrated was rejected for two market pairs, Addis Ababa causes Diksis and Addis Ababa causes Shambu. These two market pairs were not cointegrated in their linear BAR representation for which long run multipliers were not computed.

4.2. Causal Relationships

The analysis of the causal impact of price shocks in each origin market on the destination market, and vice versa is presented in Table 3. The causality of price changes at Addis Ababa on the price changes in Woliso, Debre Birhan, and Diksis markets is significant at 5% level. Addis Ababa has very strong causal effect onto Ambo and Adaba markets. The causal effect of price changes in Addis Ababa was weak and/or insignificant on other markets, but the reverse causality effect was stronger for most market pairs. Moreover, for most market pairs, this weaker causal effect of Addis Ababa market on other markets was not explained by the linear BAR model as indicated by the adjusted coefficient of determination.

On the other hand, Nazreth wheat market influences the formation of prices in Diksis strongly (1% level) while it has weak and very weak effect on Adaba and Addis Ababa, respectively. Only the Adaba market has a very weak casual effect on Nazreth. The causal relationship indicates that the effect of price changes in Nazreth on the price changes in the other markets is stronger than the effect of the Addis Ababa market on other markets, implying that Nazreth wheat market is more central as compared to the Addis Ababa wheat market. The causal relationship estimated between Addis Ababa and Nazreth was verified to be similar with the results of Kindie *et al* (2006), even though the two models and the estimation procedures are different.

Table 3: Tests of Granger causality and validation of the bivariate model for wheat prices in Ethiopia (July 2001-June 2007).

Spatial market pairs	Lag length	Causality $F = \frac{(R_{ur}^2 - R_r^2)/m}{(1 - R_{ur}^2)/(N-k)}$	Model validation (equation 2)	
			Adjusted R^2	F-value
Addis Ababa →Nazreth	0	0.472	-0.023	0.204
Addis Ababa →Ambo	2	6.044**	0.407	8.877**
Addis Ababa →Debre Birhan	0	4.017*	-0.006	0.799
Addis Ababa →Diksis	0	6.048*	-0.020	0.310
Addis Ababa →Adaba	1	33.508**	0.373	11.428**
Addis Ababa →Woliso (A)	1	2.147	0.397	6.834**
Woliso →Addis Ababa	3	8.158**	0.250	6.589**
Shambu →Addis Ababa	0	0.904	0.352	1.193
Nazreth →Addis Ababa (A)	3	1.811	0.713	22.078**
Ambo →Addis Ababa	4	14.41**	0.568	9.827**
Debre Birhan →Addis Ababa	4	18.432**	0.784	25.338**
Diksis →Addis Ababa	4	4.807**	0.805	28.687**
Adaba →Addis Ababa	0	0.767	0.236	11.795**
Woliso →Addis Ababa	3	8.158**	0.250	6.589**
Nazreth →Diksis	2	29.039**	0.649	22.286**
Diksis →Nazreth	1	2.596*[a]	0.488	17.657**
Nazreth →Adaba (B)	0	2.796	0.173	14.470**
Adaba →Nazreth (B)	0	3.458	0.394	0.362
Dessie →Mekelle	2	31.116**	0.731	32.233**
Mekelle →Dessie	1	87.432**	0.713	44.389**

Note: The results indicate that Nazreth is not granger caused by Addis Ababa wheat market. *: Causality is significant at 5% level. **: Causality is significant at 1% level. A: Very Weak causality (significant at 25% level). B: Weak causality (significant at 10% level).

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

4.3. Interim Multipliers

Based on the results obtained from estimating equation (2), Addis Ababa wheat market has a significant contemporaneous (short run) price effect only on Ambo market (1.05%). Except the Debre Birhan wheat market, all the other markets have significant contemporaneous price effects on Addis Ababa. The lag impact of the Addis Ababa market on Adaba wheat market was, however, higher. As indicated by the results of causal effects in the previous section, for most market pairs, the estimated price effects of Addis Ababa market on Nazreth and other surplus markets was weak or insignificant (Table 4).

Table 4: Contemporaneous and lagged price effects on the responses across wheat markets (July 2001-June 2007).

Spatial market pairs	Lag length (month)	Contemporaneous price effect $\beta_{i,0}$	Lagged price effects $\sum_{h=1}^{h=n_i} \beta_{i,h}$
Addis Ababa →Nazreth	0	0.155	_
Addis Ababa →Ambo	2	1.053*	-0.070
Addis Ababa →Debre Birhan	0	-0.276	_
Addis Ababa →Diksis	0	0.152	_
Addis Ababa →Adaba	1	-1.358	0.881
Addis Ababa →Woliso	1	0.701	-0.613
Nazreth →Addis Ababa	3	0.377**	0.710
Ambo →Addis Ababa	4	0.105**	0.340
Debre Birhan →Addis Ababa	4	0.090	1.347
Diksis →Addis Ababa	4	0.087**	0.383
Adaba →Addis Ababa	0	0.040**	_
Woliso →Addis Ababa	3	0.120**	0.231
Nazreth →Diksis	2	-0.139	-0.007
Nazreth →Adaba	0	0.398**	_
Diksis →Nazreth	1	0.410**	0.179
Adaba →Nazreth	0	0.012	_
Dessie →Mekelle	2	0.330**	1.017
Mekelle →Dessie	1	0.632**	-0.023

Note: *: Significant at 5%. **: Significant at 1% level

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

The significant contemporaneous price effects of Nazreth, Ambo, Diksis, Adaba and Woliso on Addis Ababa were 0.38, 0.11, 0.09, 0.04, and 0.12, respectively. The lag price effects of Nazreth, Ambo, Woliso, Debre Birhan, and Diksis were 0.71, 0.34, 0.23, 1.35 and 0.38, respectively. The higher lag effects on Addis Ababa were granger caused by Debre Birhan and Nazreth markets. There were no lag effects from Adaba market in the study period. The lag price effect of Nazreth, Ambo, Debre Birhan, and Diksis on Addis Ababa was higher indicating the dominance of these surplus markets in the process of price formation to affect the Addis Ababa wheat market. This justifies that wheat prices are first discovered at the surplus markets, and then transmitted to the destination markets. This is related to the fact that wheat prices are determined by the change in the supply of wheat, wheat supply shocks, in the surplus markets rather than the demand at the Addis Ababa wheat market. However, the price transmission from the majority of the surplus markets to the Addis Ababa market was very sluggish taking 3 to 4 months. Unlike other surplus markets, the price information transmission from Adaba market to Addis Ababa was completed within a month.

Nazreth has a significant contemporaneous effect on the other 2 markets trading with it (i.e. Addis Ababa and Adaba) and is affected only by Diksis with lower magnitude. Assuming that there is no spatial pricing conduct problem, the contemporaneous and lag effect of Nazreth on Addis Ababa indicates the central role of Nazreth in discovering wheat prices in Ethiopia. Nazreth was affecting prices in other markets including Addis Ababa very sluggishly and the reverse effect was almost insignificant.

The contemporaneous price effect of Mekelle on Dessie was higher (0.63) than the effect of Dessie on Mekelle (0.33). The lag effect of Dessie on Mekelle was 1.02. The Mekelle market contemporaneously affects prices in Dessie but, in the long-run, price effect of Dessie on Mekelle was very high indicating that Dessie was more influential than Mekelle.

The findings of this result generally indicate that prices formed in Nazreth are significantly transmitted to Addis Ababa and other surplus markets, but prices formed in Addis Ababa are not transmitted onto other markets (except Ambo). The same thing is true for the price transmission from other markets to Addis Ababa. The effect of other markets onto Addis Ababa was stronger than the effect of the other markets on Nazreth. To test whether Addis Ababa or Nazreth is the dominant market for wheat price formation in the country, there are two alternative conditions. If there is no spatial pricing inefficiency in these reference markets, then Nazreth will be the central market, and the wheat marketing system is competitive. But, if there is significant spatial price discrimination, it will be irrelevant to identify a central market in the presence of market failure or bad market structure. This is verified in the next section by employing the tests that help in identifying the spatial pricing behavior of the marketing agents operating in these markets.

4.4. Long-run Multipliers

Table 5 indicates 12 market pairs with casual relationships (67%) for which significant long-run multipliers are computed. Significant negative long-run multipliers were computed for two market pairs, i.e. Addis Ababa causes Adaba and Nazreth causes Diksis. These negative long-run multipliers cannot be defined because they have no a priori meaning. Moreover, the price adjustment takes place instantaneously, within a month, for two market pairs (Adaba causes Addis Ababa and Nazreth causes Adaba), for which long-run multipliers were not computed.

The results indicate that the cumulative effect of wheat price transmission from Addis Ababa to other markets is very much limited affecting only two markets. A 1% price change in Addis Ababa results in 0.98%, and 0.09% price changes in Ambo and Woliso, respectively. But this amount of shock in other markets leads to a price change in Addis Ababa amounting to 1.1% from Nazreth, 0.45% from Ambo, 1.44% from Debre Birhan, 0.47% from Diksis, and 0.35% from Woliso. The maximum price transmission was estimated from Debre Birhan to Addis Ababa market.

The estimated long-run price transmission from Nazreth to Addis Ababa was about 1.1% and the length of time required for the price adjustment was 3 months which is much longer than the time expected for price transmission between the two nearby markets. Interestingly, the long-run multiplier from Diksis to Nazreth was 0.59% taking 1 month to complete the adjustment. However, the percentage of price transmission from Dessie to Mekelle was 1.35% which is higher but sluggish taking at least 2 months to complete the price adjustment in Mekelle. The long-run multiplier for the price transmission from Mekelle to Dessie was 0.61%. The price transmission between Mekelle and Dessie, with a distance of 382 kilometers in between, is higher and speedier than the price transmission between Nazreth and Addis Ababa, with a distance of 100 kilometers in between.

Table 5: Estimates (A) of long-run price transmission between wheat markets (July 2001-June 2007).

Market pairs and direction of causality	Long-run multiplier $\lambda_{ij} = \lim_{k\to\infty} \lambda_{ij}^{k}$
Addis Ababa →Ambo	0.98**
Addis Ababa →Adaba (B)	-0.48**
Addis Ababa →Woliso	0.09**
Ambo →Addis Ababa	0.45**
Debre Birhan →Addis Ababa	1.44**
Diksis →Addis Ababa	0.47**
Woliso →Addis Ababa	0.35**
Nazreth →Addis Ababa	1.10**
Nazreth →Diksis (B)	-0.15**
Diksis →Nazreth	0.59**
Dessie →Mekelle	1.35**
Mekelle →Dessie	0.61**

Note: A: Only significant estimates are indicated. B: The computed long-run multipliers for the two market pairs were negative. These are considered as if there were no significant and meaningful long-run price effect between these markets. **: Significant at 1% level.
Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

The lower and sluggish price transmission between markets around the assumed reference markets could be because of the prevalent marketing system and level and distribution of factors determining spatial market integration. The results generally indicate that wheat markets in Ethiopia, except Ambo, are not very much affected by price shocks in Addis Ababa; rather price shocks in Nazreth and other supply markets highly affect prices in Addis Ababa slowly. However, the speed of price transmission from Addis Ababa to other markets is faster than the speed of price transmission from supply markets to Addis Ababa. This sluggish price transmission from supply markets might be related to the flexibility and responsiveness of the destination and the supply markets in the wheat price formation process.

4.5. Composite Index

A measure of spatial market integration combining both the magnitude and the speed of price transmission is considered as the composite index. The composite index computed for significant positive long-run multipliers is summarized in Table 6. It shows the percentage of price transmission per month. The three most integrated wheat market pairs in Ethiopia showed a composite index of 0.67% (Dessie causes Mekelle), 0.61% (Mekelle causes Dessie), and 0.59 (Diksis causes Nazreth). This means that a 1% price change in Dessie, Mekelle, and Diksis leads to 0.67%, 0.61%, and 0.59% price change per month in Mekelle, Dessie, and Nazreth, respectively. The 3 most weakly integrated market pairs were Woliso causes Addis Ababa (0.12%), Ambo causes Addis Ababa (0.11%), and Addis Ababa causes Woliso (0.09%).

Table 6: Extent of price adjustment across the major wheat markets in Ethiopia (July 2001-June 2007).

Spatial market pairs and direction of causality	**Composite index** $\mu_{ij} = \frac{\lambda_{ij}}{k_{ij}}$
Addis Ababa →Ambo	0.492
Addis Ababa →Woliso	0.087
Nazreth →Addis Ababa	0.365
Debre Birhan →Addis Ababa	0.359
Diksis →Addis Ababa	0.118
Woliso →Addis Ababa	0.117
Ambo →Addis Ababa	0.113
Diksis →Nazreth	0.589
Dessie →Mekelle	0.674
Mekelle →Dessie	0.609

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

4.6. Pricing Behavior

The price discovery by an organized action of traders could make spatial markets highly integrated while they are not actually integrated in the long-run. A high degree of price integration among markets does not necessarily imply that the marketing system is functioning properly (Tilburg and Lutz, 1995). The three hypothesized pricing conduct of oligopolistic markets were tested in the selected wheat markets (Table 7). All the market pairs with significant short-run or long-run multipliers were tested for the 3 hypothesized pricing conduct models.

The first hypothesis, which tests the presence of spatial price discrimination, was accepted in some market pairs trading with Addis Ababa and Nazreth. Addis Ababa plays a discriminatory role on supply markets without alternative market outlets, and supply markets with attentive outlets discriminate these destination markets. This indicates that supply markets exercise discriminatory role on the destination markets if prices are not better than prices in alternative market outlets including Mekelle and Kenya. The absence of long-run price transmission form Addis Ababa to Nazreth might be related to the pricing conduct of traders in Addis Ababa. The remaining two hypotheses, *i.e.* perfect cooperative pricing and price matching with offsetting lags, were rejected for all the market pairs. The exercise to cooperatively fix and match prices between two markets was not accepted for all market pairs. However, no market pair was identified for its competitive pricing system because not all hypotheses were rejected for all market pairs. This is explicit evidence about the presence of noncompetitive pricing behavior in the wheat markets.

Table 7: Tests of spatial pricing conduct in the major Ethiopian wheat markets (July 2001-June 2007).

Spatial market pairs and direction of causality	t tests for unity contemporaneous price effect $H_0: \beta_{i,0} = 1$; $H_1: \beta_{i,0} < 1$	Hypothesized spatial pricing behavior (F tests)		
		Hypothesis I: Spatial price discrimination	Hypothesis II: Instantaneous and perfectly cooperative pricing	Hypothesis III: Perfect price matching with offsetting lags
Addis Ababa →Nazreth	-25.431**	0.351	0.401	0.401
Addis Ababa →Ambo	0.891	8.906**	9.234**	7.819**
Addis Ababa →Debre Birhan	-48.7479**	0.540	1.642	0.077
Addis Ababa →Diksis	-13.670**	0.817	2.671	1.238
Addis Ababa →Adaba	-23.237**	2.739*	14.059**	0.930
Addis Ababa →Woliso	-5.212**	8.244**	8.259**	11.987**
Nazreth →Addis Ababa	-104.845**	32.888**	8.666**	12.026**
Ambo →Addis Ababa	-293.036**	3.613**	6.855**	3.359**
Debre Birhan →Addis Ababa	-80.964**	13.924**	28.073**	16.799**
Diksis →Addis Ababa	-266.901**	35.616**	26.743**	32.623**
Adaba →Addis Ababa	-803.194**	9.767**	10.001**	14.859**
Woliso →Addis Ababa	-250.230**	4.232**	4.055**	3.924**
Shambu →Addis Ababa	-258.015**	0.891	0.505	0.188
Nazreth →Adaba	-65.412**	10.090**	7.581**	10.096**
Nazreth →Diksis	-73.916*	10.179*	26.433*	9.114*
Diksis →Nazreth	-96.790**	22.172**	1.219	1.814
Adaba →Nazreth	-551.080**	1.329	0.949	0.055
Dessie →Mekelle	-84.325**	16.955**	24.648**	19.510**
Mekelle →Dessie	-20.664**	13.105**	42.477**	19.183**

Note: *: Significant at 5% level. **: Significant at 1% level.

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

Market pairs with spatial price discrimination as tested in Table 7 were identified and separately presented in Table 8. The nature of spatial price discrimination or market independence between destination (Addis Ababa and Nazreth) and supply markets can be verified by examining the reverse price transmission, the availability of alternative market outlets for supply markets, and the price levels and pricing conduct prevalent in the destination markets.

The price changes in Nazreth, Debre Birhan, and Diksis were transmitted to Addis Ababa, but there was no price transmission from Addis Ababa to these markets. The significant price transmissions estimated from Addis Ababa were negative to Adaba (-0.48%), and very small to Woliso (0.09%). The magnitude of price transmission from Ambo was the only meaningful and indicative measure estimated. As explained in the previous sections, the effect of price transmission from other markets to Addis Ababa was high and significant but the reverse effect on other markets was discriminatory. Out of the 5 markets which have high and significant price effects on Addis Ababa, Ambo was the only wheat market that was highly and significantly affected by the Addis Ababa market. The discriminatory role of the destination markets was offset by using alternative market outlet in Adaba, Debre Birhan, and Shambu. The price discrimination by Adaba on Nazreth, Addis Ababa on Debre Birhan, and Shambu on Addis Ababa is expected to be the result of alternative trade route change to Adaba-Awassa-Kenya, Debre Birhan-Dessie-Mekelle, and Shambu-Bahir Dar-Mekelle, respectively. The supply markets without alternative market outlets like Ambo and Woliso were not significantly discriminated.

Table 8: Wheat markets with spatial price discrimination (July 2001-June 2007).

Spatial market pairs and direction of causality	Long-run price transmission	F tests for price discrimination
Addis Ababa →Nazreth	Discriminated	Accepted
Addis Ababa →Debre Birhan	Discriminated	Accepted
Addis Ababa →Adaba	Negative	Rejected
Addis Ababa →Woliso	Very small	Rejected
Adaba →Nazreth	Discriminated	Accepted
Shambu→Addis Ababa	Discriminated	Accepted

Note: **: Significant at 1% level.

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

This is a strong evidence to justify that wheat marketing middlemen in Addis Ababa fix prices discriminatively. They exercise spatial price discrimination on traders operating in other markets of Ethiopia. This means that retail price changes formed in Addis Ababa were protected from transmission onto other markets by the action of marketing middlemen in this destination market. The price discrimination could be used to secure high spatial margins which might be shared among suppliers in supply markets and buyers in Addis Ababa by protecting the price shock in Addis Ababa from transmission. This mechanism could avoid transmission of price shocks to supply markets so that prices will not rise in the supply markets and the maximum spatial margins would be secured in destination markets. These marketing middlemen, as verified by Eleni (2001), might include the powerful brokers in Addis Ababa.

However, it is also empirically justified by the results that traders in Nazreth did not (or did not able to) fix prices discriminatively on other markets. That is why price changes in Nazreth were highly reflected in Addis Ababa. Supply market like Adaba and Shambu change their market outlets and try to establish short-run market independence. Generally, the test for spatial price discrimination justifies the presence of problem of pricing behavior in destination markets and the actions taken by supply markets to overcome the problem. The wheat marketing system in Ethiopia was verified to suffer from inefficient pricing system.

4.7. Determinants of Spatial Integration

In this section, the three market integration measures, *i.e.* long-run multipliers, speed of price adjustment, and composite index were used for analyzing the effect of structural factors on market integration. Five structural factors of wheat market integration were hypothesized to determine the level of integration of wheat markets in Ethiopia. These factors were inter-market road distance, road density surrounding the two markets, DPCP, and DPD between the two markets and the number of production shocks. The relevance and the functional form of the variables were specified by AIC procedure. According to production data in CSA for 2001/02-2006/07 production years, there was no significant wheat production shock in the area surrounding the selected markets and the number of production shocks as a variable was not included in the analysis. Moreover, out of the remaining four variables, DPD was not relevant variable for all the market integration measures. The estimation indicates that, except DPD, the other three variables were relevant to determine the level of wheat market integration in Ethiopia (Table 9).

Table 9: Validation and summary results of the structural determinants of wheat market integration (July 2001-June 2007).

Factors of spatial integration and validation techniques	Coefficients (equation 13)		
	Speed of adjustment (months)	Long-run multiplier	Composite index
Road distance	-0.686**	-0.314*	-0.087
Road density	1.408**	0.817**	0.358*
DPCP	-0.092	-0.352**	-0.228**
Adjusted R^2	0.883	0.840	0.695
d statistic	1.713	2.170	2.061
F-value	33.642	20.202	9.365

Note: .Only significant estimates are presented. *: Significant at 5% level. **: Significant at 1% level.

Source: Computed from data in CSA and Annual Reports of Regional Roads Authorities (Amhara, Oromia, Tigray, and Addis Ababa), various issues.

The model fitness, as validated by the adjusted coefficient of determination, is high (at least 70%) for all the integration measures estimated. The fitness was 88.3% for the speed of adjustment, 84.0% for the long run multiplier, and 69.5% for the composite index. The case wise diagnostics indicate that the residuals from the regression were stationary as validated by the computed d-statistics implying that the models are properly specified and the relevant variables included. It is found that the fitness of the models relatively decreases as the accuracy of the integration measures increase. Generally, the result indicates that the selected factors were relevant and sufficiently explain the amount and the sources of the variation in market integration. However, about 12% to 30% of the variation in market integration measures was not explained by the assumed structural factors requiring further studies to identify other structural, institutional, and policy factors of integration.

Distance is expected to influence market integration negatively. Its effect on the market integration was negative as expected for all measures of integration. As the distance between the spatial markets decreases, the integration of the markets increases. Road density of the area surrounding the markets was positively related with all market integration measures as expected. It significantly and positively affects wheat market integration. It was generally observed that the magnitude of the parameter estimates decreases as the accuracy (or robustness) of the integration measures increases.

In competitive markets, it is expected that as DPCP between two markets increases, there will be a price increase in the origin markets as a reflection of the price increase in the destination market. This increases the movement of stocks from surplus to deficit markets. However, DPCP between markets was negative for all measures and significant for the long-run multipliers and the composite index while it was insignificant for the speed of adjustment. The probable reasons for the negative effect of DPCP on market integration could be the result of the problem in the pricing conduct and instability of prices and transaction costs which engenders risk and reduces spatial arbitrage. The instability of prices causes instability of spatial margins thereby decreasing their predictability.

5. Conclusions

This paper has evaluated the level of spatial wheat market integration, the pricing conduct of traders, and the structural determinants of spatial market integration. The analysis was conducted at three stages. First, the various market integration measures were estimated and tested. In the second stage, the pricing conduct of traders in the markets was tested for competitiveness. Finally, the identification of structural factors that determine market integration and estimation of their parameters was conducted. Among other things, it has estimated the dynamics of price relationships and the temporal causation in wheat markets, and has empirically verified that the problem of pricing conduct was prevalent in these markets by explicitly testing for its presence. The major structural factors of market integration were identified and tested for their relative importance in affecting the extent of market integration.

Inter-market price transmission was found to be sluggish in Ethiopian wheat markets for the period specified in the study. The estimated market integration measures and their tests indicate that, in most markets, spatial wheat price adjustment was generally delayed (taking a month and above). This is the result of the lack of competitiveness and flexibility of the agricultural marketing system in the country.

Spatial wheat markets even within 100 kilometers distance did not adjust instantaneously. These markets need one or more months to complete their adjustment to price changes occurred in other nearby markets.

The result indicates that Addis Ababa has a dominant role in fixing prices discriminatively and controlling the price transmission to other supply markets. The underlying assumption of a well-integrated marketing system is its flexibility to transmit prices across different localities (Goletti and Christina-Tsigas, 1995). Prices were discovered in both Addis Ababa and Nazreth but there was no price transmission from Addis Ababa to supply markets. Traders in Addis Ababa respond to the price shocks that are caused in supply markets slowly and protect the price changes within them from transmittal to these markets. This indicates that they work to widen the spatial price differential without sharing it to the producers and the retailers in the supply markets. Nazreth was found to be relatively competitive central wheat market in the discovery and transmission of wheat prices.

The spatial price discrimination in Addis Ababa was the result of the pricing conduct, which, in turn, was the cause for the negative relationship between market integration and DPCP. This is a serious problem for the marketing system in that it creates shortages in destination markets, and surpluses in origin markets. Both consumers in deficit urban markets and producers around surplus markets are, therefore, affected by the problem. The problem of pricing conduct creates a general problem of allocation of resources, if it is not avoided by appropriate legal and marketing measures.

Moreover, four structural factors of market integration were estimated and tested for their effect on spatial price adjustment to identify potential market improvement strategies. The magnitude of market integration and the speed of spatial price adjustment were found to be highly related with the level (size and distribution) of the selected structural factors of integration. The degree of integration and the speed of price adjustment between markets have significant policy implications in that the timing and the location of policy interventions should consider these indicators. Among other things, the following policy implications are derived.

a. The magnitude and speed of price transmission between markets should be improved by developing the determinant structural, institutional, and policy factors of market integration;
b. Spatial pricing conduct problems should be corrected by legal intervention measures to help improve the dynamics of price adjustment process;
c. To formulate cost-effective policy intervention measures and to identify the importance of a commodity in price stabilization process, the empirical knowledge on inter-market and inter-commodity price dynamics should be improved by further studies.

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