MTID DISCUSSION PAPER NO. 66

GRAIN MARKETING POLICY CHANGES AND SPATIAL EFFICIENCY OF MAIZE AND WHEAT MARKETS IN ETHIOPIA

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February 2004

ACKNOWLEDGEMENTS

We are very grateful to Thomas Jayne, John Staatz, John Strauss, John Pender and an anonymous referee for their very helpful comments and suggestions. We would also like to thank Ashok Gulati for his very kind support in this work. The financial support of International Food Policy Research Institute (IFPRI) through the project on "Policies for Sustainable Land Management in the Ethiopian Highlands" is gratefully acknowledged. However, any errors and omissions are solely our responsibility.

ABSTRACT

In the context of on-going market reform in developing countries, there is a need for an improvement in the existing methods of spatial market efficiency analysis in order to better inform the debate toward designing and implementing new grain marketing policies, institutions, and infrastructure that facilitate the emergence of a well developed and competitive grain marketing system. The standard parity bounds model (PBM), while it overcomes many weaknesses of the conventional methods of spatial market efficiency analysis, it does not allow for the test of structural changes in spatial market efficiency as a result of policy changes. In this paper, building on the standard PBM, we develop an extended parity bounds model (EPBM). The EPBM is a stochastic gradual switching model with three trade regimes. The EPBM is estimated by maximum likelihood procedure and allows for tracing the time path and structural change in spatial market efficiency conditions due to the policy changes. We applied the EPBM to analyze the effect of grain marketing policy changes on spatial efficiency of maize and wheat markets in Ethiopia. The results show that the effect of policy changes on spatial market efficiency is not significant statistically in many cases; there is high probability of spatial inefficiency in maize and wheat markets before and after the policy changes. The implication of these results is that maize and wheat markets are characterized by periodic gluts and shortages, which can undermine the welfare of producers, grain traders and consumers. It is also observed that the nature of spatial inefficiency for maize and wheat markets is different implying that the two commodities might require different policy responses in order to improve spatial market efficiency. Maize traders made losses most of the time while wheat traders made excess profits most of the time covered by the study.

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1. INTRODUCTION

During the socialist Derg-regime, the Ethiopian government maintained a heavy interventionist approach in its grain marketing policies. Through marketing parastatals and cooperatives, the government controlled grain prices and restricted interregional grain movements and private traders participation in the grain trade. The effects of these policies on the development of grain markets, the agricultural sector, and the national economy have been well studied (e.g. Lirenso, 1987; Franzel et al., 1989; Dadi et al., 1992). In more recent years, however, the Ethiopian government has embarked on various market reform measures to address the problem of poor grain market performance. Many questions remain regarding the speed of adjustment in grain market performance in response to policy changes, and how these policy changes are affecting spatial grain marketing efficiency in Ethiopia.

It has been argued that the management of market reform requires an understanding of the operation of local markets, the strategies and responses of private traders, and how both relate to changes in the institutional and policy environment of markets (Kherallah et al., 2002). Such an understanding is crucial to the design, implementation, and evaluation of marketing policies, institutions, and marketing

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infrastructure required for the development of grain markets. The key challenge now is to move beyond market liberalization to the issue of how to design input and output markets to catalyze smallholder productivity and income growth (Jayne et al., 2002).

In spatial price analysis, the terms "spatial market efficiency" and "spatial market integration" are very widely used, sometimes interchangeably. However, there has been a growing recognition that these terms are related but not equivalent, and that there is a need to distinguish between them (Fackler, 1996; McNew, 1996; McNew and Fackler, 1997; Fackler and Goodwin, 2001; Barrett et al., 2000; Barrett and Li, 2002). Spatial market efficiency is an equilibrium condition whereby all potential profitable spatial arbitrage opportunities are exploited. Spatial efficiency is concerned with whether the *optimal* amount of trade is occurring. This optimality condition requires that spatial price differentials be less than or equal to transfer costs, equal with trade. If there is no trade, a spatial price differential less than transfer cost is also consistent with spatial market efficiency. However, if the spatial price differential is greater than transfer cost the market is inefficient either with or without trade.

On the other hand, spatial market integration is defined as the extent to which demand and supply shocks arising in one location are transmitted to other locations (Fackler, 1996; McNew, 1996; McNew and Fackler, 1997; Fackler and Goodwin, 2001). Observing direct trade flows between two spatially distinct markets is a sufficient but not necessary condition for some degree of spatial market integration (Barrett et al., 2000; Barrett and Li, 2002). Direct trade linkages between regions are not necessary for spatial integration because if regions belong to a common trading network then price shocks may be transmitted indirectly through the network (Fackler and Goodwin, 2001). Markets that are not well integrated may transmit inaccurate price information that distorts marketing decisions and contributes to inefficient product movements (Goodwin and Schroeder, 1991).

Market integration has usually been conceived in terms of the co-movements or long-run relationship between spatial prices (Fackler, 1996). However, spatial integration is neither necessary nor sufficient for spatial efficiency (and vice versa) so that tests for integration do not always generate the appropriate inference regarding spatial market efficiency (Fackler, 1996; McNew, 1997; McNew and Fackler, 1997; Fackler and Goodwin, 2001; Barrett et al., 2000; Barrett and Li, 2002). It is argued that the conventional methods assume methods assume stationary spatial marketing margins, stationary transfer costs, and/or that markets are linked by a constant trade pattern (uni-directional and continuous). However, these assumptions are often violated and so the resulting test of market integration may be misleading and have adverse consequences on policy decisions. The development of the parity bounds model (PBM) represents one attempt to make the distinction between spatial market integration and spatial market efficiency more clear, while overcoming most of the weaknesses of the conventional methods of testing for market integration. When data on prices, transfer costs and trade flows are simultaneously available, the PBM allows a clear distinction between spatial market efficiency and spatial market integration (Barrett and Li, 2002).

The effects of policy changes on spatial grain market efficiency can be either instantaneous or gradual. The standard PBM has been used mostly to analyze spatial grain market efficiency within a given (constant) marketing policy regime (e.g. Sexton et al., 1991; Fafchamps and Gavian, 1996; Baulch, 1997; Barrett et al., 2000; Barrett and Li, 2002; Penzhorn and Arndt, 2002). In cases where it has been used to analyze the effects of marketing policy changes on spatial market efficiency, the effect of policy changes is assumed to be instantaneous (e.g. Park et al., 2002). This involves simply estimating a different PBM for different sub-periods, with each sub-period corresponding to a different policy regime. However, the PBM may be mis-specified and the results and policy implications might be misleading if the actual effect of marketing policy changes on spatial market efficiency is gradual and moves through a transition period, as might be expected in many cases. It may take some time for the traders to learn and understand the new marketing policy changes, assess its implications for reorganizing their businesses, make new investment and disinvestment decisions, and to access resources required to make the necessary adjustments in response to policy changes.

In general, the standard PBM does not allow for a test of a structural change in spatial grain market efficiency due to policy changes. Knowledge of the time path of the effects of market reform on spatial market efficiency would be very useful for properly assessing the effects of marketing policy changes on spatial market efficiency, and for designing marketing policies, institutions and marketing infrastructure. Thus, there is a need to improve and extend the standard PBM so that it allows for gradual transition between spatial market efficiency states as a result of changes in the policy environment, and to develop a test of whether such structural changes in spatial market efficiency are statistically significant.

Another problem with implementing the PBM empirically is that time series data on transfer costs are rarely available, particularly in developing countries like Ethiopia. As a result, most empirical PBM studies have assumed transfer costs are equal to a constant plus a serially uncorrelated error for a given marketing policy regime (e.g. Sexton et al., 1991; Fafchamps and Gavian, 1996; Baulch, 1997; Barrett et al., 2000; Barrett and Li, 2002; Penzhorn and Arndt, 2002). However, this assumption is very restrictive, particularly when the PBM is used to analyze the effects of policy changes. This is because if transfer costs are assumed to be equal to a constant plus a serially uncorrelated error when they actually fluctuate systematically over time, then the PBM may misinterpret spatial price deviations as evidence of inefficiency when they are actually just a rational response to changes in transfer costs. Thus, there is a need to go beyond the conventional constant transfer cost assumptions and find better ways of using data that are available to construct more appropriate inferences about historical movements in transfer costs.

In October 1999, in its continued market reform process, the Ethiopian government amalgamated the Ethiopian Grain Trade Enterprise (EGTE) with the Ethiopian Oil Seeds and Pulses Export Corporation (EOPEC) and re-established it as a public enterprise. The amalgamated EGTE is not required to intervene directly to stabilize grain prices, and its major objective is commercial profitability by focusing on exportable grains (Bekele, 2002). The effect of the changes in the EGTE's organizational structure and its reduced role in stabilizing grain prices, on spatial grain market efficiency has not been studied so far. Such information should be useful to policy makers, researchers, and donor communities interested in understanding the effects of grain price stabilization policy changes on grain market development in Ethiopia. It would inform the debate concerning the design and implementation of new grain marketing policies that facilitate the emergence of a well developed and competitive grain marketing system in Ethiopia, and may have implications for other developing countries involved in their own market reform processes.

There are two major objectives in this study: (1) to provide an improved modeling approach for analyzing the adjustment path and the extent of structural change in spatial grain market efficiency in response to policy changes; and (2) to provide empirical evidence on the dynamic adjustment path of structural changes in spatial market efficiency for maize and wheat in Ethiopia as a result of grain marketing policy changes implemented in October 1999.

A stochastic gradual switching model is developed which builds on the standard parity bounds model and extends it in two ways. First, the extended model traces the adjustment path of spatial efficiency changes in response to policy changes and tests whether the effect of a policy change is instantaneous or gradual. If it is gradual, the model also allows determination of the length of time required for the transition from old to new spatial efficiency regime. Second, the extended model allows for statistical tests for structural change in spatial efficiency regimes due to the policy changes. In the process of implementing the extended PBM model to study spatial market efficiency in Ethiopian grain markets, it is shown how the standard transfer cost assumptions can be generalized, even if a full time series of transfer cost data are not available, as long as one has access to cross-sectional transfer cost data for particular periods that have been collected via trader surveys and time series data on truck shipment freight rates.

The remaining sections of the paper are organized as follows. The following section provides a detailed specification of the parity bounds model and extends it to enable analysis of the dynamic effects of marketing policy changes on spatial grain market efficiency. The data sources and descriptions are given in section three. The empirical results for maize and wheat are presented in section four. Finally, the summary and conclusions are provided in section five.

2. EMPIRICAL MODEL

In Ethiopia, there is a great diversity among different regions in terms of their agricultural production conditions such as soils, climate, and rainfall. As a result, it has been observed that some regions have excess supply while other regions have excess demand which gives rise to the possibility of interregional grain trade. This section discusses the conceptual framework for analyzing the performance of interregional grain trade in terms of efficiently allocating grain over space. Building on the standard parity bounds model, an empirical model that allows for an adjustment path and a test of structural change in spatial market efficiency due to policy changes is developed and outlined.

2.1 CONCEPTUAL FRAMEWORK

A recent review of models used in spatial price analysis can be found in Fackler and Goodwin (2001). In general, empirical tests of the performance of spatially separated markets are conducted within the framework of spatial price equilibrium (SPE) theory developed by Enke (1951), Samuelson (1964) and Takayama and Judge (1964). The key prediction of this theory is that price relationships between spatially separated competitive markets depend on the size of transfer costs. In particular, in spatially efficient markets the price difference between regions engaged in trade should be less than or equal to transfer costs.

Consider two markets located in different regions (i and j) that may engage in trade for a given homogenous commodity. For the two regional markets, the autarky prices (prices which equalize the supply and demand in respective regional markets without trade) at time *t* for market *i* and *j* can be represented as:

(1) $P_{it}^{A} = \alpha_{it} + \zeta_{it}$

(2) $P_{jt}^{A} = \alpha_{jt} + \zeta_{jt}$

where α_{it} and α_{jt} are time varying mean autarky prices which depend on supply and demand shifters in the local markets, and ζ_{it} and ζ_{jt} are stochastic disturbance terms affecting the autarky prices in the respective regional markets. The transfer costs, TC_{jit}, for conducting interregional trade between the two regional markets at time t is modeled as a random variable with time varying mean transfer costs, γ_{jit} and random component e_{jit}:

(3) $TC_{jit} = \gamma_{jit} + e_{jit}$

where e_{jit} is normally distributed with mean zero and variance σ_e^2 for all trade regime probabilities. Given the above formulation of autarky prices and transfer costs, three mutually exclusive and exhaustive spatial arbitrage conditions or trade regimes could be identified based on the relative sizes of contemporaneous spatial price differentials and transfer costs.[4]

In regime one, trade may or may not be occurring and the spatial price differential is equal to transfer cost:

(4) $P_{it} - P_{jt} = TC_{jit}$

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[18] The assumption of contemporaneous relationship between spatial prices can also be relaxed. Thus, trading regimes that take into account the lag/lead relationships between the spatial market prices can also be formulated.

where P_{it} and P_{jt} are contemporaneous prices in the i^{th} and j^{th} regional markets, respectively. This is a condition for a spatially efficient market either with or without trade. In this regime, due to competitive pressure in the marketing system, the traders are not making excessive or economic profits from regional trade. With trade between the two regional markets, the actual prices P_{it} and P_{jt} may differ from the autarky prices and the price movements in different markets are related due to changes in either market's supply and demand conditions or the stochastic disturbance terms.

In regime two, the spatial price differential is less than transfer cost and is given as:

(5) $P_{it} - P_{jt} < TC_{jit}$.

This regime represents a market condition where no profitable arbitrage opportunities exist between the two markets. The two markets may be in autarky but prices are efficient. However, if there is trade it is inefficient because traders are making losses. This indicates that efficient allocation does not necessarily require physical trade flows between markets. In this regime the autarky prices and the efficient prices are identical in the respective regional markets. The prices in the two regions are independent due to very high transfer costs, and shocks are not transmitted across the markets.

Finally, regime three is given as a condition where trade may or may not be occurring and the spatial price differential is greater than the transfer cost:

(6) $P_{it} - P_{jt} > TC_{jit}$.

In this regime, the spatial arbitrage condition is violated and the markets are not efficient but may be integrated to some extent if some trade is occurring. In this regime, there are opportunities for profitable spatial arbitrage that are not being exploited. If the markets are efficient, competition is expected to equalize the spatial price differentials and transfer costs, and the transfer costs are the largest price difference that can exist between two markets engaged in trade. It is argued that violation of the spatial arbitrage condition is an indication of the existence of impediments to trade between markets and should be considered as evidence supporting the lack of perfect market integration (Baulch, 1997). Among several conditions that may lead to regime three is the existence of transportation bottlenecks, non-competitive pricing practices, government controls on product flows between regions, government price support activities, licensing requirements, and quotas (Tomek and Robinson, 1990; Baulch, 1997). The empirical model is discussed next.

2.2 THE EXTENDED PARITY BOUNDS MODEL

The empirical model developed here to analyze the effects of the policy changes on spatial grain market efficiency is a stochastic gradual switching model. Building on the earlier work of Baulch (1997), Sexton et al. (1991) and Spiller and Wood (1988), this model extends the standard PBM in two ways. First, it traces the time path of the effects of the policy changes on the spatial efficiency regime probabilities. This allows determination of whether the effect of the policy changes is instantaneous or gradual and if it is gradual the approach also allows the determination of the time period required for the full effects of the policy changes to be realized. Thus, the extended model provides a better understanding of the nature of transition from old to new policy regime. Second, the extended PBM also allows for statistical tests of structural change in the probabilities of spatial efficiency regimes due to the policy changes.

Let the probability of regimes one, two, and three defined as before be λ_1, λ_2, and λ_3, respectively. Suppose that transfer costs are unobservable but known to be related to an (possibly biased) observable transfer cost estimate γ^o_{jit}. Then, the unobservable transfer costs can be modeled as:

(7) $$TC_{jit} = \beta_0 + \beta_1 \gamma^o_{jit} + e_{jit}$$

where γ^o_{jit} is the observable transfer cost estimate, β_0 and β_1 are unknown parameters and ejit is a random shock.[5] The γ^o_{jit} is also given as:

(8) $$\gamma^o_{jit} = \alpha_1 FR_t + \alpha_2 (P_{jit} + \alpha_1 FR_t)$$

where α_1 is the proportion of transport cost in the interregional grain trade computed from cross-sectional surveys of grain traders, FR_t is the freight rate at time t and α_2 is traders normal profit assumed to be 7% of the sum of grain purchase price (P_{jit}) plus $\alpha_1 FR_t$. Then, assuming that spatial prices and transfer costs are stochastic and the transfer cost between the two markets is independent of the direction of trade flows, we can redefine the conditions for regimes one, two and three given in equations (4), (5) and (6), respectively, as follows:

(9) $$\left|P_{it} - P_{jt}\right| - \beta_0 - \beta_1 \gamma^o_{jit} = e_{jit}$$

(10) $$\left|P_{it} - P_{jt}\right| - \beta_0 - \beta_1 \gamma^o_{jit} = e_{jit} - u_{jit}$$

(11) $$\left|P_{it} - P_{jt}\right| - \beta_0 - \beta_1 \gamma^o_{jit} = e_{jit} + v_{jit}$$

where u_{jit} and v_{jit} are non-negatively valued random variables that measure the deviation (if any) between price differentials and transfer costs. The error terms e_{jit}, u_{jit}, and v_{jit} are assumed to be normal, half-normal, and half-normal independently distributed random variables with standard deviation equal to σ_e, σ_u, and σ_v, respectively. The e_{jit} is an error term which applies to the transfer costs. The u_{jit} and v_{jit} are composite error terms

[5] The detailed discussion of the procedures used in the construction of grain transfer costs from cross-sectional surveys of grain traders and time series data on truck shipment freight rates is given in section 3.

of the disturbance terms in the demand and supply functions for the pair of markets considered, and their magnitude depends on the relative imbalances between demand and supply in individual markets.

In regime one, the markets are spatially efficient and the variance of the spatial price differentials is given by the variance of transfer costs between the two markets, σ_e^2. In other words, the variability in the spatial price differentials is explained fully by the variability in the transfer costs between the two markets. Then, the parity bounds (or confidence interval) for the spatial price differentials can be constructed using the variance of the disturbance term for regime one and the exogenously given or endogenously estimated transfer costs. Thus, the parity bounds for spatial price differentials can be given as $\beta_0 + \beta_1 \gamma_{jit}^o \pm Z\sigma_e$, where Z is a critical value for normal distribution at a given statistical significance level. On the other hand, the variance of the spatial price differentials under the autarky condition is given as $\sigma_e^2 + \sigma_u^2$ while the variance of spatial price differentials for regime three is given as $\sigma_e^2 + \sigma_v^2$.

Let the contemporaneous difference between spatial price differentials and transfer costs be given as a random variable $\pi_t = |P_{it} - P_{jt}| - \beta_0 - \beta_1 \gamma_{jit}^o$, where π_t can be considered as expected "economic" profit made from regional trade.[6] Then, the joint probability density function for π_t over the entire trading regime is given as:

$$(12)\quad f_t(\pi_t \mid \theta) = \lambda_1 f_{1t}(\pi_t \mid \theta) \quad + \quad \lambda_2 f_{2t}(\pi_t \mid \theta) \quad + \quad (1 - \lambda_1 - \lambda_2) f_{3t}(\pi_t \mid \theta)$$

where λ_1, λ_2 and $\lambda_3 = (1 - \lambda_1 - \lambda_2)$ are defined as before; the f_{it}'s are mixture normal distributions which are given for regime one, two, and three, respectively; and θ is a parameter vector (λ_1, λ_2, λ_3, β_0, β_1, σ_e^2, σ_u^2, and σ_v^2) to be estimated. The probability density function for regime one is the ordinary normal density function while for regime

[6] The spatial price differential is also corrected for losses during storage and transporting grain and the procedure used is discussed in chapter 6.

two and regime three the density functions are truncated half-normal density functions and are given as follows:

$$(13)\quad f_{1t} = \frac{1}{\sigma_e}\varphi\left[\frac{|P_{it} - P_{jt}| - \beta_0 - \beta_1\gamma^o_{jit}}{\sigma_e}\right]$$

$$(14)\quad f_{2t} = \left[\frac{2}{\left(\sigma_e^{\,2} + \sigma_u^{\,2}\right)^{1/2}}\right]\varphi\left[\frac{|P_{it} - P_{jt}| - \beta_0 - \beta_1\gamma^o_{jit}}{\left(\sigma_e^{\,2} + \sigma_u^{\,2}\right)^{1/2}}\right]\left[1 - \Phi\left[\frac{\left(|P_{it} - P_{jt}| - \beta_0 - \beta_1\gamma^o_{jit}\right)\frac{\sigma_u}{\sigma_e}}{\left(\sigma_e^{\,2} + \sigma_u^{\,2}\right)^{1/2}}\right]\right]$$

(15)

$$f_{3t} = \left[\frac{2}{\left(\sigma_e^{\,2} + \sigma_v^{\,2}\right)^{1/2}}\right]\varphi\left[\frac{|P_{it} - P_{jt}| - \beta_0 - \beta_1\gamma^o_{jit}}{\left(\sigma_e^{\,2} + \sigma_v^{\,2}\right)^{1/2}}\right]\left[1 - \Phi\left[\frac{-\left(|P_{it} - P_{jt}| - \beta_0 - \beta_1\gamma^o_{jit}\right)\frac{\sigma_v}{\sigma_e}}{\left(\sigma_e^{\,2} + \sigma_v^{\,2}\right)^{1/2}}\right]\right]$$

where φ (.) and Φ (.) denote the standard normal probability density and cumulative distribution functions, respectively.

The likelihood function for π_t based on the joint probability density functions defined above for the different trade regimes over the entire study period is given as:

$$(16)\, L = \prod_{t=1}^{T}\left[\lambda_1 f_{1t} \quad + \quad \lambda_2 f_{2t} \quad + \quad (1 - \lambda_1 - \lambda_2) f_{3t}\right].$$

The parameters can be obtained by maximizing the logarithm of the above likelihood function using numerical optimization. However, this is the standard PBM that does not allow us to see the adjustment paths and the effects of the policy changes on the probabilities of different trade regimes.

Park et al. (2002) were the first to apply the PBM to analyze the effects of market reform on spatial market efficiency. Park et al. (2002) estimated the relative frequencies of realized spatial arbitrage opportunities for Chinese grain markets over four sub-periods under the implicit assumption that the effects of policy changes on the regime probabilities are instantaneous. Here, however, we allow both for instantaneous and gradual change in regime probabilities due to the policy changes. In other words, our model allows us to estimate the length of adjustment period required for the full effects of policy changes to be realized.

Our proposed PBM extension changes the standard PBM from a stochastic switching model to a stochastic switching model with gradual probability changes. Hereafter we call this the extended parity bounds model (EPBM). The model allows the identification of time paths characterizing the structural changes in regime probabilities as a result of the policy changes. It is possible that there may be immediate adjustment from the old to the new policy regime, which implies that the full effects of the policy changes are instantaneous or abrupt. However, the assumption of instantaneous adjustment in market conditions in response to policy changes may be unrealistic. It might take some time for the traders to learn and understand the new policy changes, assess the implications for reorganizing their business, make investment and disinvestment decisions, and to obtain resources required to make necessary adjustments. The EPBM allows determining the path of structural changes in regime probabilities as a result of the policy changes.[7]

[7] The information on the nature of the adjustment path across several markets is useful to see if there are differential responses to policy changes among different markets and to determine what policy changes are required in order to speed up the response.

To accomplish the above objectives we modify the joint probability density function and likelihood function for standard PBM given in (12) and (13) as follows:

(17)

$$f_t(\pi_t \mid \theta) = \lambda_1 f_{1t}(\pi_t \mid \theta) \quad + \quad \delta_1 D_t f_{1t}(\pi_t \mid \theta) \quad + \quad \lambda_2 f_{2t}(\pi_t \mid \theta) \quad + \quad \delta_2 D_t f_{2t}(\pi_t \mid \theta) \quad +$$

$$(1 - \lambda_1 - \lambda_2 - \delta_1 D_t - \delta_2 D_t) f_{3t}(\pi_t \mid \theta)$$

(18)

$$L = \prod_{t=1}^{T} \left[\lambda_1 f_{1t} \quad + \quad \delta_1 D_t f_{1t} \quad + \quad \lambda_2 f_{2t} \quad + \quad \delta_2 D_t f_{2t} \quad + \quad (1 - \lambda_1 - \lambda_2 - \delta_1 D_t - \delta_2 D_t) f_{3t} \right]$$

where δ_k measures the structural change in the probability of being in regime *k* due to the policy changes and D_t is a transition variable, which characterizes the alternative time path of structural change in regime probabilities and is constructed following Ohtani and Katayama (1986) as described below.

Let the end date of the old marketing policy regime and the beginning date for realization of the full effect of the new policy on regime probabilities be denoted by τ_1 and τ_2, respectively. Then, D_t takes the value of 0 for τ_1 and earlier dates, between 0 and 1 for the period between τ_1 and τ_2, and 1 for τ_2 and later dates. The length of period between τ_1 and τ_2 represents the length of transition period required for the adjustment in the grain marketing system before the full effects of the policy changes on trade regime probabilities are realized.

The pattern of transition from τ_1 to τ_2 can be represented using different functional forms (linear or non-linear). Figure 2.1 shows alternative linear time paths for the transition from τ_1 to τ_2 as represented by different D_t's. For example, if the length of transition period is 10 months then 1/10 (10%) of the adjustment occurs every month and by the 5^{th} month half of the adjustment is complete. Thus, the linear functional form for the transition period assumes constant speed of adjustment over the whole transition period.[8] In our model, τ_1 is known but τ_2 is treated as a parameter to be estimated. The log likelihood function is maximized for different possible τ_2 values and the τ_2 value that has the maximum log likelihood function is selected. The different lengths of transition period are captured by using N-τ_1 different transition variables corresponding to each time period since the introduction of the new policy regime, where N is the total number of observations. In our case, N-τ_1 is equal to 35 and thus the number of maximized log likelihood values is 35.

The approach followed here is similar to that of Moschini and Meilke (1989), which is used in the estimation of the time path of structural change in U.S. meat demand. However, there is one basic difference between our approach and Moschini and Meilke (1989). In the case of Moschini and Meilke (1989), both the starting date (τ_1) and the end date (τ_2) are to be estimated from the model. But in our case the starting date is known and only the end date is to be estimated from the model. The optimum length of transition period is given by the length of time elapsed between τ_1 and τ_2. The case where τ_2 is equal to τ_1+1 (a period immediately after the policy changes) represents abrupt or instantaneous change in policy regime, which implies no transition period.

On the other hand, τ_2 greater than τ_1+1 represents a gradual transition from old to the new policy regime. The length of transition period depends on the flexibility that grain traders have to make investment or disinvestment decisions as deemed necessary in response to the new marketing policy changes. It also depends on the extent of awareness of grain traders about the new marketing policy changes and how they perceive the effects of policy regime changes on their grain business operation. It can be hypothesized that different grain traders in different regions have different capacity and ability to assess and respond to changes in the marketing policy environment.

[8] In other studies of structural changes, functional forms which allow for different speed of adjustment during the different times of the transition period are also used (for example, see: Goodwin and Brester, 1995).

The case where the effect of the policy changes is instantaneous is a special case of EPBM, which is equivalent to separately estimating the PBM parameters for different sub-periods. This corresponds to the Park et al. (2002) specification. The joint test of structural changes in all regime probabilities is conducted using the likelihood ratio test based on the restricted (no structural change) and unrestricted EPBM parameter estimations. The restricted EPBM is estimated by setting all δ's to zero which means under the null hypothesis of no structural change the LR test statistic is χ^2 distributed with three degrees of freedom. In addition, where the LR test shows significant structural change, individual t-tests are used to test significance of EPBM parameters. For example, statistically significant values for δ_k indicate that there has been structural change in the probability of trade regime *k* as a result of a given policy change.

Thus, the probabilities for the different trade regimes are determined simultaneously for the three periods: (1) period before the policy changes, (2) during the transitional period, (3) the period during the full effect of the policy changes. For example, a time path of structural change in a regime probability where the probability has increased as a result of policy change is given for a hypothetical case in Figure 2.2. For the period before the policy changes, the probability estimates for the different trade regimes are given by λ_i. On the other hand, the probability estimates for the transition period and after the full effect of the policy changes is realized are given as:

(19) $\lambda_i + \delta_i D_t$.

Since the parameter estimates are probabilities, the probabilities for a given time period should add up to one over the entire trade regimes, which requires the impositions of the following restrictions during the estimation procedure:

(20) $0 \le \lambda_i \le 1$

(21) $0 \le \lambda_i + \delta_i \le 1$

(22) $\sum \lambda_i = 1$

(23) $\sum \delta_i = 0$

In general, the EPBM represents an improvement over the standard PBM in that it allows tracing of the time path and a statistical test of structural change in spatial market efficiency due to the policy changes. However, the EPBM also has several weaknesses similar to that of the standard PBM which are discussed by Fackler (1996). First, the results are often sensitive to the distributional assumptions made. Second, the difficulty in accurately estimating the transfer costs might also bias the results. Third, there is also the identification problem that any estimated effects may be due to other changes that occurred around the time of the policy change.

2.3 ESTIMATION PROCEDURES

There are four basic stages in EPBM estimation. The first stage is to collect grain prices and transfer cost data. The second stage is to specify the appropriate log likelihood function to be maximized using a maximization algorithm. The third stage is to determine the optimum time length required for the transition from old to new policy regime. The optimum time length is determined by maximizing the value of log likelihood function for all possible time lengths of transition period. Finally, the EPBM parameters estimates are obtained conditional on the optimum length of time required for the transition from the old to the new policy regime.

The log likelihood function being maximized to obtain EPBM parameters estimates is highly non-linear. As a result, there are two major problems that might be encountered in numerical maximization: (1) the existence of multiple local maxima, and (2) lack of convergence. There are several strategies that can be used to tackle these problems, as discussed in the TSP users guide (Hall and Cummins, 1999). These strategies include: (1) the choice of appropriate maximum likelihood estimation algorithm, (2) the choice of appropriate starting values, and (3) grid search on certain difficult parameters or full grid search on all parameters. In addition, graphical analysis of the relationship between spatial price differentials and the transfer costs series is also useful in assessing the EPBM estimates.

There are several algorithms provided in TSP to maximize the log likelihood function. In our case, we used the Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm, which is found to perform best in our situation as compared to other algorithms available. The BFGS uses analytic first derivatives and a rank one update approximation to the Hessian (Hall and Cummins, 1999). During the estimation procedure, the values of regime probabilities are restricted to the range between 0 and 1 and the standard deviations are also restricted to be positive using implicit functional forms.

Figure 2.1 Alternative Linear Time Paths of Structural Change in Trade Regime Probabilities (1996:08 to 2002:08)

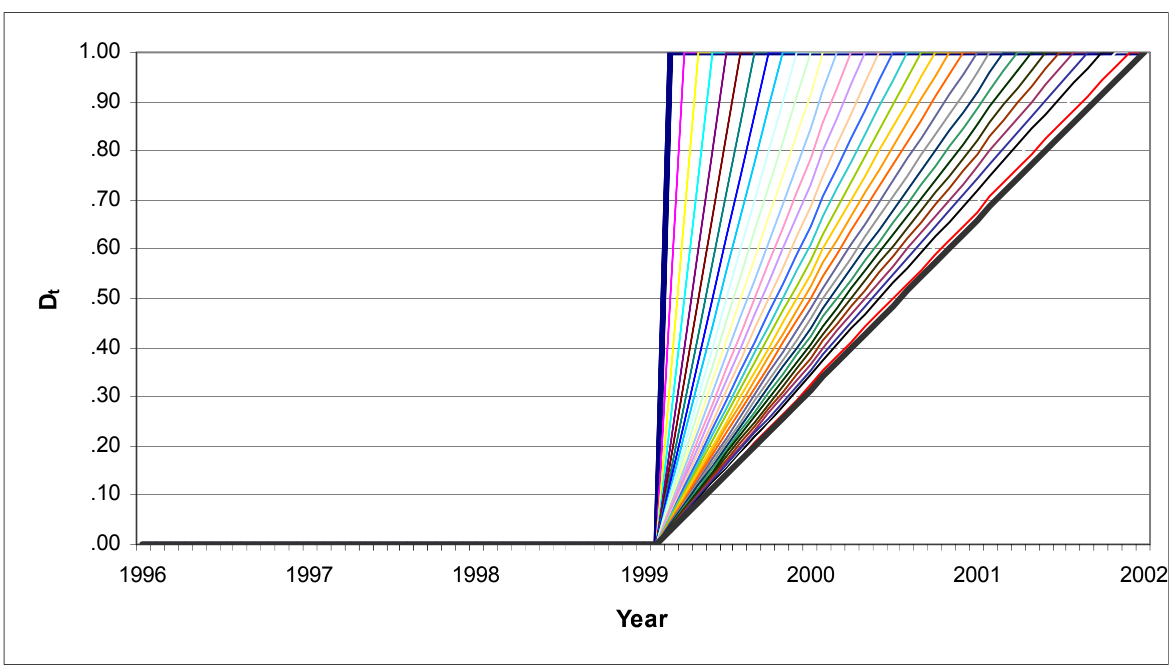
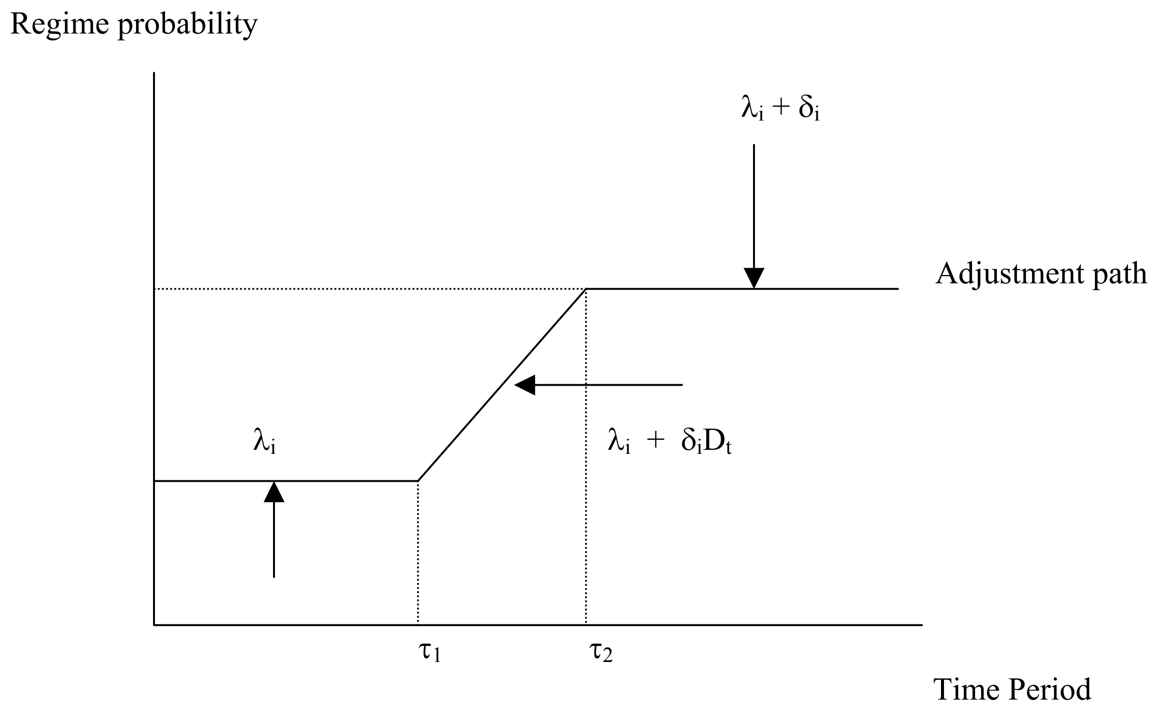


Figure 2.2 Time Path of Structural Change in Trade Regime Probability due to the Policy Changes for a Hypothetical Case



3. DATA

There are two cereal crops, white maize and white wheat (from now on, simply referred to as maize and wheat), which are considered in this study based on completeness of the dataset available, importance in interregional grain trade, and degree of homogeneity of consumer preferences. *Teff*, which is a very important staple crop in Ethiopia, is not included in this study due to the difficulties involved in examining spatial price relationships among regional *teff* markets. This is because *teff* varieties grown in different locations are heterogeneous and consumer preferences for these varieties are variable, but the available *teff* price data for Addis Ababa and other regional markets are based only on the color of *teff*. The more appropriate *teff* price data needed for spatial price analysis would be collected by color and origin of *teff*.

The main data required for estimating the parity bounds model are wholesale grain prices for different markets, interregional grain transfer costs and the start date for the new policy regime. For this purpose, weekly wholesale maize and wheat price data are obtained from the Ethiopian Grain Trade Enterprise (EGTE) for the period from August 1996 to August 2002. There are ten important markets, which are considered in this study, which are either from grain surplus areas or grain deficit areas. The markets selected from the surplus producing regions include Addis Ababa, Bale Robe, Hosanna, Jimma, Nazareth, Nekempte, and Shashemene, while the markets selected from the deficit regions include Dessie, Dire Dawa, and Mekele. Most of these markets are considered in the spatial price analysis of both maize and wheat, while few are considered only for either maize (e.g., Jimma and Nekempte) or wheat (e.g., Bale Robe and Hosanna).

Since August of 1996, the EGTE has collected weekly price data for different varieties of five major cereal crops at different stages of the vertical marketing channels (producer, wholesale and retail) in 26 markets. The cereal crops consisted of maize (white and yellow), *teff* (white, mixed, and red), wheat (white, red, mixed, and food aid wheat), sorghum (white, yellow, and red), and barley (white, black and mixed).[9] The price data are collected by EGTE field staff who transmit weekly price data to the EGTE's headquarters in Addis Ababa by telephone. Then, the price data are entered into computer spreadsheets and compiled for further analysis or for distribution of raw data to various users.

The weekly price series are converted into monthly series by taking the unweighted mean of weekly price observations for a given month. The weekly price series is converted into monthly price series for two main reasons. First, the frequencies of transfer costs were monthly or annual, so monthly aggregation is needed to have comparable levels of aggregation for both wholesale prices and transfer costs. Second, the use of low frequency (monthly or annual) price data is recommended in order to allow sufficient time for the realization of inter-market arbitrage (Baulch, 1997).

The EGTE has also collected qualitative weekly grain flow data for the same markets and this data available for the periods from August 1997 to June 1998 and from January 1999 to August 2002. The grain flow data collection was interrupted for six months, from July 1998 to December 1998. This period coincides with the last phase of the Grain Market Research Project. After GMRP was phased out in 1998, the grain price and flow data collection has continued with the financial support from the European Union (EU). For the selected commodities, the EGTE grain flow dataset consists of market level weekly data on total quantity purchased in the market, percentage purchased outside the market, the first and second most important sources of grain inflows to the market, total quantity sold in the market, percentage sold outside the market and the first and second most important destinations of grain outflows from the market.[10]

[9] A well-organized and systematic grain price and flow data collection was started by Grain Market Research Project (GMRP) in August of 1996 having EGTE as an institutional home. The Grain Market Research Project was a collaborative research project among Ministry of Economic Development and Cooperation (MEDaC) of Ethiopia, Michigan State University (MSU) and USAID/Ethiopa.

[10] The important sources and destinations markets are determined based on subjective assessment of EGTE's filed staff and no actual grain flows are recorded by sources and destinations.

Interregional grain transfer costs are estimated using cross-sectional surveys on marketing costs of interregional grain trade and time series truck shipment freight rates data. The marketing costs of interregional grain trade are calculated based on two cross-sectional surveys of grain traders in Ethiopia. The first survey was conducted by Gabre-Madhin in 1996 while the second one was conducted in 2002 by International Food Policy Research Institute (IFPRI) and International Livestock Research Institute (ILRI). These surveys document detailed marketing costs on the latest transaction involving either intraregional or interregional grain trade.

Monthly and annual time series freight rates data are collected from MEDaC and the Ministry of Transport Authority (MTA) for the period from 1993 to 2002. The portion of freight rate dataset series which is available only on an annual basis is converted into a monthly series using a monthly freight rate index constructed from the monthly freight rate series. Next, the construction of estimate of total grain transfer costs using these two sources of data are discussed.

A complete time series data on interregional grain transfer cost is rarely available, particularly in developing countries like Ethiopia. Given this problem, several approaches have been used in measuring the transfer costs data needed for the implementation of the PBM. If time series transfer cost data is readily available, it can be considered exogenous in the PBM analysis (e.g., Barrett et al., 2000; Barrett and Li, 2002). However, if time series transfer cost data is not available, there are two alternatives. The first alternative is to estimate the transfer costs using the PBM based on the observed spatial price differentials (e.g., Park et al., 2002). However, this implicitly assumes a time invariant transfer cost. The second alternative is to estimate transfer cost data either using the marketing cost computed from grain trader surveys and adjusting for inflation (e.g., Baulch, 1997) or inflating the time series transport cost data by a certain percentage to account for the unmeasured components of transfer costs (e.g., Penzhorn and Arndt, 2002).

In our case, the specific procedures used in calculating interregional grain transfer costs data for the implementation of the EPBM are as follows. The first step is to calculate variable marketing costs for recently completed interregional grain trade from cross-sectional surveys of grain traders. Following Gabre-Madhin (1996), the marketing cost is classified into eight broad categories: sacking, handling, storage, transport, roadblocks, broker's service, travel, and tips and others. The average variable marketing costs estimated for both 1996 and 2002 are roughly the same, about 26 Birr/100 kg (Table 3.1). An examination of the structure of variable marketing costs indicates that the transport cost is one of the most important components of the cost. For example, in 1996 about 61% of variable marketing cost is attributed to transport while in 2002 this percentage is 72%. The unweighted average percentage of transport cost in the variable marketing cost for the two sample grain traders' surveys is found to be 68.16%.[11]

In the second step, the computed unweighted average percentage of transport cost is applied to time series freight rate data in order to obtain time series data on variable marketing costs. For example, if transport cost accounts for 50% of the variable marketing cost then, the time series variable marketing cost data is generated by multiplying the time series freight rates by two.[12]

The opportunity cost of the wholesale grain trader as a manager of a grain business is also included in the computation of the variable marketing cost of regional grain trade. Thus, the computed value of interregional grain transfer cost is given as the sum of the variable marketing costs and regional grain traders' 'normal' profit margin (see equation 8). In the context of regional grain trade, the 'normal' profit margin could

[11] The percentage of transport cost in the variable marketing cost is computed for the aggregate overall surveyed markets instead of computing it for individual markets or specific trade routes. This is because of limited number of observations for individual markets and trade routes in the grain trader surveys. The assumption of constant percentage of transport costs in marketing costs is very strong and implies that the only source of temporal variation in the transfer cost data is the freight rate. However, here the transfer cost computed from the trader's survey is used only as a starting point in the EPBM estimation. Hence the assumption of constant percentage might not be as restrictive as is it initially appears.

[12] The fixed/ operating costs like vehicle maintenance, storage and pest control, taxes and fees, wages, losses and costs of capital are difficult to obtain and are not included in the computation of marketing cost.

be the minimum profit the regional wholesale trader would be willing to accept to engage in interregional grain trade. In other words, the normal profit is what the regional trader would earn from the second best alternative employment. There is no readily available estimate of traders' normal profit in Ethiopia. In this study, following Dessalegn et al. (1998), the regional grain traders' normal profit is assumed to be 7% of the sum of wholesale grain price in the exporting market and variable grain marketing costs.[13] Finally, the computed interregional grain transfer costs is used as a regressor in the subsequent parametric estimation of interregional grain transfer costs and trade regime probabilities using the EPBM.

The spatial price differentials are obtained by taking the differences between the wholesale grain prices in the importing and exporting markets after adjusting the wholesale prices in the importing markets for grain losses (due to, for example, weight losses, pests, spillages, etc.,) in the process of exporting grain. In this study, an average of 2.18% grain loss in transporting grain from one regional market to another is assumed based on the estimate from grain trader survey by Dessalegn et al. (1998). They indicated that 83% of the surveyed merchants experience weight loss ranging from 0.1% to 16%. Thus, the importing market wholesale prices are multiplied by 0.9782 (1-0.0218) to obtain the spatial price differentials used in the EPBM estimation.

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[13] Conceptually, the opportunity cost of those engaged in grain trade must be included in the computation of grain transfer cost. However, there is difficulty in obtaining accurate opportunity cost for managers of grain trade business and as a result very rough assumptions are made regarding trader's normal profit. For example, Baulch (1997) adds certain fixed margins to the freight rates in order to derive the transfer costs. In our case, the normal profit is given as 7% of marketing costs and grain purchase price in the export market. The actual normal profit margin could be lower or higher than 7%. However, this assumption may not have a very significant impact on the EPBM results as the transfer costs computed from trader surveys are used only as starting points in the parametric estimation of transfer costs using the EPBM.

4. EMPIRICAL RESULTS AND DISCUSSIONS

Without information on the actual grain trade flow data, it is generally not possible to estimate the exact probabilities of being in spatially efficient and spatially inefficient regimes. This is because regime one (with or without trade) represents spatially efficient arbitrage and regime three (with or without trade) represents spatially inefficient arbitrage, but regime two could be either spatially efficient (without trade) or spatially inefficient (with trade). In the presence of a significant probability of regime two, actual trade flow data are required to separate the probability of regime two into spatially efficient and inefficient outcomes. The EGTE grain flow data is used in the interpretation of trade regime probabilities estimated by EPBM. Thus, in order to facilitate the presentation of empirical results we first provide a brief description of EGTE grain flow data involving the markets included in this study.

The minimum observed frequencies of maize and wheat trade flows for selected market pairs are given in Table 4.1. The frequency of flow data for a given market pair is determined based on the weekly observations of first and second most important sources and destinations markets for a given commodity.[14] The flow data is observed on a weekly basis and aggregated to monthly flow observations and the frequencies reported here are based on the number of months for which trade flow was observed out of the possible 26 months before the policy changes and 35 months after the policy changes.

The minimum frequency of maize flows between selected markets varied from 15% to 100%. The lowest frequency of maize flow is observed between Dire Dawa and Nazareth prior to the policy changes. After the policy changes, the frequency of

[14] Furthermore, the frequencies are minimum observations because the information on trade flows when the market is less important (e.g., when a commodity ranks third, fourth, fifth, etc.,) as source or destination market is not collected. Thus the actual frequencies of trade flows could be equal or higher than the frequencies reported here.

maize flow decreased for 3 of 7 market pairs, increased for 3 of 7 market pairs and remained the same for one market pair. In the case of wheat, the frequency of trade flow varied from 39% to 100% for the period before the policy changes, and after the policy changes the frequency of trade flow increased in two cases, decreased in two cases and remained the same in three cases. In general, even with limited grain flow data, it is observed that most of the selected market pairs are linked by continuous trade flows for most of the time during the study period.

4.1 EMPIRICAL RESULTS FOR MAIZE

Empirical results from the EPBM are given in Table 4.2 for selected maize market pairs.[15] The conditional maximum likelihood estimates of trade regime probabilities (λ's), the change in trade regime probabilities (δ's) due to the policy changes, and the standard deviations of profit for different trade regimes (σ's) are shown at the top of Table 4.2. The estimated lengths of transition periods, the values of the log likelihood for restricted (no structural change) and unrestricted estimations, the chi-square (χ^2) statistics for likelihood ratio (LR) tests of the joint hypothesis of no structural change in regime probabilities, and the number of observations used in the analysis are shown at the bottom of Table 4.2. The plots of the sizes of losses or gains from inefficient trade for selected maize market pairs are given in Figure 4.1.

For the period before the policy changes, the probability of regime one (λ_1), where the spatial price differential is equal to transfer cost, is less than 1% and statistically significant at the 1% level for 3 of 7 selected maize market pairs. It varied from 20% to 34% for the other 4 of 7 selected market pairs. Thus, prior to the policy changes, the probability of the spatial price differential being equal to transfer cost, which is consistent with spatial market efficiency whether or not trade is actually occurring, is very low for most market pairs and, less than 35% for all market pairs.

[15] A Monte Carlo experiment is conducted to investigate the performance of EPBM estimation procedure and improve understanding of how the PBM works. The detailed discussion of the design and the results of simulation using the EPBM are given in Asfaw, 2004.

On the other hand, the probability of regime two (λ_2), where the spatial price differential is less than transfer cost, is found to be large and statistically significant at the 10% level for all maize market pairs. For example, the probability of being in regime two prior to the policy changes are greater than 65% and statistically significant at the 1% level for 6 of 7 selected maize market pairs. Regime two can also be consistent with spatial market efficiency if no trade is occurring between the markets. If trade does occur in regime two, then it is presumably conducted at a loss, which would be inconsistent with spatial market efficiency.

During the same pre-policy change period, the probabilities of regime three (λ_3), where the spatial price differential is greater than transfer cost, is found to be small but statistically significant in most cases. The only large and statistically significant probability of regime three is observed between Addis Ababa and Mekele, which has a 68% probability of regime three, which is statistically significant at the 1% level. Of course, regime three is spatially inefficient whether there is trade or not because there are arbitrage profits from potential trade.

In general, the period before the policy changes is characterized by large and statistically significant probabilities of the spatial price differential being less than transfer cost, while the probability of the spatial price differential being greater than or equal to transfer cost is generally small. This indicates that the probability of profitable spatial arbitrage opportunities (probability of regime one plus probability of regime three) for maize prior to the policy changes is very low for the selected maize market pairs. The fact that regime two dominates also indicates that there is a high probability that maize traders made losses during this period, if they engaged in actual trade.

The one exception to the above conclusion is Addis Ababa – Mekele, which was estimated to have a 68% probability of spatial price differential greater than transfer cost, indicating spatial inefficiency and potential gains from additional trade. This result is consistent with the observation of strict and persistent control on grain flows from Addis

Ababa to the Tigray region, which might have created maize shortages in Tigray and increased prices there. The purpose of the grain movement control was to raise tax revenue. The grain movement control was enforced through a roadblock raised at Alamata, a small town which is strategically situated on a major grain route connecting Addis Ababa to Mekele. It is a strategic location because grain traders who want to ship grain to Mekele from or via Addis Ababa do not have any better alternative route by which they can avoid this roadblock. Grain can also enter Tigray via Gonder in the North. However, this route involves longer distance and its costs may have exceeded the roadblock charge at Alamata. Thus, the ability of regional maize traders to take advantage of profitable spatial maize trade opportunities between Addis Ababa and the Tigray region is limited by this regional grain trade block.[16]

With very large and statistically significant estimated probability of spatial price differential less than grain transfer costs, one would generally expect very low maize flow among these markets during this period, because spatial arbitrage would be unprofitable. In other words, the probability of market segmentation is very high. However, a close examination of maize flow data between these markets during this period shows that there have indeed been frequent maize flows between these markets. This would suggest maize traders were engaged in maize trade but were making losses which indicate spatial inefficiency.[17]

For example, based on the EGTE's grain flow data, maize trade flow between Jimma and Addis Ababa and Wellega and Addis Ababa occurred at least for 95% of the months prior to the policy changes (Table 4.1). At the same time the probabilities of spatial price differential less than transfer cost is at least 75%. These results indicate there is high probability of spatial maize market inefficiency prior to the policy changes. Generally, western maize producing regions like Jimma and Wellega have a limited

[16] The roadblock charges are included in the computation of grain transfer costs. However, it is difficult to capture the whole magnitude of the roadblock charge from a few cross-section surveys. For example, the time wasted at the roadblock, the spoilage and quality deterioration, missed market opportunities can't be easily quantified from cross-section surveys.

[17] This result might also be due to aggregation error in the prices and transfer costs which masks periods when trade was profitable.

export outlet for surplus maize production, and it is commonly observed that, even when prices are relatively low in Addis Ababa, maize exports to Addis continue from these regions. Hence, prices continue to fall in Addis Ababa. Grain traders in surplus producing regions have the option to sell their grain in their local markets when the price in Addis Ababa or other regional markets is not favorable. However, the surplus absorption capacities of local markets are limited.

There are several factors which might cause spatial inefficiency of maize markets in which there is high probability of making losses by maize traders. First, the lack of well-developed storage facilities in maize supply markets might force the continuous flow of grain to central or other deficit markets, even if maize prices are not favorable in these markets. The rationale for this might be to reduce further revenue losses because of waiting for better price which might lead to spoilage, quality deterioration, and maize prices in the maize destination markets might also further decrease while waiting. Second, liquidity constraints and shortage of working capital due to missing or imperfect credit markets for grain traders can also force maize traders to liquidate grain, even if it means a loss. It has been observed that grain traders in Ethiopia have poor access to formal credit and other forms of financial services. The authors' personal observation of grain markets indicate that proceeds from current grain (e.g., maize) sales are used by grain traders for refinancing future grain purchases and settling other debts which indicate that the opportunity costs of capital tied up in grain stock is very high when the grain traders have limited access to credit.

Third, regional maize wholesale traders might have difficulty matching profitable purchase and sale decisions due to inadequacy or unavailability of market information regarding future price movements and changes in supply and demand conditions in the source and destinations markets. Fourth, there may be too many maize traders but these traders might lack economies of scale in their operation contributing to higher cost of marketing. Fifth, maize traders might also be limited by their grain trading skills to adjust to the very dynamic grain marketing situations.

If inefficient (unprofitable) trades are taking place a natural question to ask is: how do maize grain traders survive in the long-run in the face of high probability of making losses? It is observed that the wholesale grain trade is not a specialized business in Ethiopia. Regional grain traders usually keep a diversified portfolio of business activities (grain and non-grain) and that might help to spread the risks. Regional grain traders also combine interregional grain trade activities with local grain trade activities. A lot of grain traders are also observed to operate without a license, while those with a license complain about the unfair competition from unlicensed grain traders (Dessalegn et al., 1998). Operating without a license might allow grain traders (experienced or new) to enter and exit out of the grain trade sporadically, depending on market conditions, and still avoid government tax payments hence reducing their marketing costs.

The other possible reason why the grain traders might survive could be due to the offsetting or compensating effects of fewer but larger gains for many but smaller losses. In order to investigate this issue we have computed the size of losses or gains from trade and plotted these for selected maize market pairs in Figure 4.1. The sizes of losses or gains from trade are computed as a proportion of the difference between spatial price differential and transfer costs to the cost of grain plus the transfer cost. The plots show a few episodes of unusually very high gains for most maize market pairs and there are also episodes of very high losses. However, in order to exactly determine the compensating effects of larger gains we need data on the total volume of grain transacted.

There are also indications that it might still be profitable for large-scale wholesale grain traders to engage in spatially profitable arbitrage even when smaller wholesale grain traders find it unprofitable. Osborne (1997) argues that large and small wholesale grain traders in Ethiopia have different cost structures because of economies of scale. This means that large wholesale traders can sell at the same price as the smaller traders and still make a profit because of lower cost.

The standard deviations of “economic” profit from spatial arbitrage estimated for different trade regimes are statistically significant at the 5% level for 19 of 21 cases. For each market pair, the standard deviation estimated for regime three (σ_v) is found to be the largest. As regime three is unambiguously inefficient, this indicates that the variability in the "economic" profit from spatial arbitrage is higher when the market is inefficient. It is also observed that the standard deviations of regime two are higher than that of regime one in 5 of 7 cases. The other important observation regarding variance estimates is that the standard deviations for market pairs involving Addis Ababa and deficit markets are larger than the standard deviations involving Addis Ababa and surplus markets. This indicates that the degree of risk in trading maize is relatively higher between Addis Ababa and grain deficit markets than Addis Ababa and grain surplus markets.

Likelihood ratio (LR) statistics are used to test the joint hypothesis of no structural change in trade regime probabilities due to the policy changes for selected maize market pairs, after having estimated the optimal adjustment path to the policy changes.[18] The chi-square statistics for the LR tests are presented at the bottom of Table 7.2. The results show that there is no statistically significant joint structural change in trade regime probabilities for 4 of 7 maize market pairs (Jimma and Addis Ababa, Addis Ababa and Dessie, Nazareth and Dire Dawa, and Shashamane and Dire Dawa) at the 10% level. On the other hand, the joint structural change in trade regime probabilities is statistically significant at the 5% level in 3 of 7 maize market-pairs, which include Addis Ababa and Nekempte, Addis Ababa and Dire Dawa and Addis Ababa and Mekele.

To some extent, the variation in the responses of regional maize markets to the recent policy changes can be explained by the history of government market interventions, which have varied from region to region and may have different effects on the levels of private sector grain development and grain traders' perceptions of risk and uncertainty. Generally, the markets where the policy change appears to have had little effect appear to be where the private sector grain trade already had been relatively more tolerated by the government marketing agencies during socialist regime (e.g., Nazareth and Shashamane).

[18] Optimal adjustment paths were chosen based on a likelihood maximization procedure, as discussed earlier. The optimal adjustment path estimates will be explained in more detail below.

During the socialist regime, it was observed that private grain trade in Southern Ethiopia was much more tolerated by government marketing agencies than in other regions of Ethiopia (Osborne, 1997). So the degree of risk and uncertainty perceived due to the presence of EGTE in these markets might have already been low and the recent policy changes might not bring significant change in the attitude and operations of private grain traders. On the other hand, the joint structural change in regime probabilities is statistically significant for trade between Nekempte and Addis Ababa. Nekempte is located in a maize surplus producing region and has historically been one of the major focuses of government marketing activities (private grain trade sector was highly suppressed). So in this case the changes in policy appear to have had an effect. Structural change is also significant for trade between Addis Ababa and Dire Dawa and Addis Ababa and Mekele markets. Dire Dawa and Mekele markets are also grain deficit areas where there had been heavy government intervention.

Of three maize market pairs with statistically significant joint structural change in trade regime probabilities, Addis Ababa and Nekempte and Addis Ababa and Mekele adjusted to the new policy changes gradually over a period of less than or equal to six months while the trade between Addis Ababa and Dire Dawa adjusted instantaneously (Table 4.2). The variation in the length of transition period among market pairs indicates that the speed by with which grain traders adjust to new policy regimes may depend on their location. The market pairs where the speed of adjustment is gradual appear to be where the marketing infrastructure, like road network and grain storage, is relatively less developed (e.g., Nekempte) and the destination market is far from surplus producing areas and drought affected (e.g., Mekele). On the other hand, where the adjustment is instantaneous (Dire Dawa) infrastructure is more developed with grain traders engaging in relatively larger purchases having more storage capacity, longer experience in the grain trade, and better road networks connecting the markets with other regional markets.

For markets where there is statistically significant structural change as a result of policy changes, individual t-tests on the structural change parameters (δ's) are evaluated to investigate the effect of the policy changes on trade regimes probabilities. With the policy changes, there is a large shift to regime three for Addis Ababa and Nekempte and Addis Ababa and Dire Dawa, which suggests unexploited spatial arbitrage opportunities have increased and spatial market efficiency has therefore declined. The probability of spatial price differential less than transfer cost also decreased for both market pairs but Addis Ababa and Nekempte experienced a large decrease, which is statistically significant at the 5% level. However, the change in the probability of spatial price differential equal to transfer cost is not statistically significant at the 5% level for both market pairs.

For Addis Ababa and Mekele the probability of spatial price differential equal to transfer cost increased and the change is statistically significant at the 5% level. The probability of spatial price differential less than transfer cost also increased slightly but is not statistically significant at the 10% level. The probability of spatial price differential greater than transfer cost decreased considerably and this is statistically significant at the 5% level. The large decrease in the probability of spatial price differential greater than transfer cost, and corresponding large increase in the probability of spatial price differential equal to transfer cost, suggests an increase in spatial market efficiency.

In general, prior to the policy changes all the maize market pairs considered are spatially inefficient with high probability. It is observed that the probability of spatial price differential less than transfer cost is greater than 65% for 6 of 7 maize market pairs, while the frequency of trade flow observed for these market pairs appears to be significant. Together, these results indicate that grain traders were active but made loses during this period. In other words, too much trade was taking place relative to that which we would expect in a spatially efficient market. Policy changes had statistically significant effect on regime probabilities at the 5% level in 3 of 7 maize market pairs. However, as a result of the policy changes the spatial maize market efficiency has improved only for trade between Addis Ababa and Mekele, while for the other market pairs spatial efficiency either deteriorated (Addis Ababa and Dire Dawa) or was not affected (the rest of market pairs).

4.2 EMPIRICAL RESULTS FOR WHEAT

The empirical results for selected wheat market pairs are given in Table 4.3. The conditional maximum likelihood estimates of trade regime probabilities (λ's), the change in trade regime probabilities (δ's) due to the policy changes, and the standard deviations of profit for different trade regimes (σ's) are shown at the top of Table 4.3. The estimated lengths of transition period, the values of the log likelihood for restricted (no structural change) and unrestricted estimations, the chi-square (χ^2) statistics for LR tests of the joint hypothesis of no structural change in regime probabilities, and the number of observations used are shown at the bottom of Table 4.3. The plots of the sizes of losses or gains from inefficient trade for selected wheat market pairs are given in Figure 4.2.

For the period before the policy changes, the probability of spatial price differential equal to transfer cost is less than 1 % and statistically significant at the 1% level for all wheat market pairs. Thus, the probability of the spatial price differential being equal to transfer cost, which is consistent with spatial market efficiency whether or not trade is actually occurring, is almost zero in all wheat market pairs.

The probabilities of spatial price differential less than transfer cost are also found to be less than 1% and statistically significant at the 1% level for 5 of 7 wheat market pairs. The probability of spatial price differential less than transfer cost is greater than 80% and statistically significant at the 1% level only for Addis Ababa and Dessie, and the Dire Dawa and Nazareth market pairs. From EGTE flow data (Table 4.1), it is observed that the frequencies of wheat flow for the same market pairs are 100% which indicate strong trade flows even when the price differential does not cover transfer cost. This is inconsistent with spatial market efficiency.

However, prior to policy changes, the probabilities of spatial price differential greater than transfer cost are found to be very large and statistically significant at the 5%

level in most of the cases. For example, in 5 of 7 selected wheat market pairs (Bale Robe and Addis Ababa, Hosanna and Addis Ababa, Addis Ababa and Dire Dawa, Addis Ababa and Mekele and Shashamane and Dire Dawa), the probability of spatial price differential greater than transfer cost is found to be greater than 99% and statistically significant at the 1% level. For the period before the policy changes, a small probability of spatial price differential greater than transfer cost is observed only between the Addis Ababa and Dessie, and Nazareth and Dire Dawa wheat market pairs.

Thus, in the case of wheat, the period before the policy changes is characterized by large and statistically significant probability of spatial price differential greater than transfer cost, while the probability of spatial price differential less than or equal to transfer cost are, with few exceptions, very small and mostly not statistically significant. The very large probabilities of spatial price differential greater than transfer cost indicate that the wheat markets are spatially inefficient. This could be due to the lack of competition in wheat wholesale trade either in the production areas or consumption areas. This could also be due to shortages of wheat supply in these markets resulting from restrictions on grain movement such as through roadblocks at Alamata. The high probability estimates of regime three are consistent with the observations of high frequency of wheat flow between pairs of markets considered but the quantities supplied might not be sufficient to meet the local demand.

Prior to the policy changes, the frequency of wheat trade flow between Addis Ababa and Bale Robe is 89% while it is 100% between Addis Ababa and Hosanna (Table 4.1). However, given the normal or bumper harvests for most of the time before the policy changes, observing a high probability of spatial price differential greater than transfer cost is more consistent with lack of competition or due to restrictions in wholesale wheat trade than the shortages of wheat to be supplied to these markets. In this regard, a high concentration ratio of wheat wholesale trade is also observed for some markets like Shashamane and Nazareth (Dessalegn et al., 1998). A high concentration ratio is one of the conditions for anti-competitive behavior in the market. Even though wheat grain traders made profit most of the time during the study period, there are also periods when wheat traders made very high losses (Figure 4.2). For example, for Addis Ababa and Mekele wheat market pairs a loss which is greater than 20% was observed.

The standard deviations of “economic” profit from spatial arbitrage estimated for different trade regimes are statistically significant at the 5% level for 16 of 21 cases. For each wheat market pair, the standard deviation estimated for regime three (σ_v) is found to be the largest in 5 of 6 cases. As regime three is unambiguously inefficient, this also indicates that the variability in the “economic” profit from spatial arbitrage is higher when the market is spatially inefficient.

Likelihood ratio (LR) statistics are used to test the joint hypothesis of no structural change in trade regime probabilities due to the policy changes for selected wheat market pairs. The chi-square statistics for the LR tests are presented at the bottom of Table 4.3. The results show that there is no statistically significant joint structural change in trade regime probabilities for 6 of 7 wheat market pairs, at the 10% level. On the other hand, the joint structural change in trade regime probabilities is statistically significant at the 5% level for just 1 of 7 wheat market pairs.

Structural change due to the policy effect is significant only for Addis Ababa and Mekele, which also shows instantaneous adjustment to the policy changes. For this market pair, with the policy changes there is no change in the probability of spatial price differential equal to transfer cost. However, the probability of spatial price differential less than transfer cost increased and is statistically significant at the 5% level. The probability of spatial price differential greater than transfer cost also decreased and this decrease is statistically significant at the 5% level. This result is consistent with the decrease in trade flow between Addis Ababa and Mekele which changed from 92% prior to the policy changes to 66% after the policy changes (Table 4.1). In general, as result of policy changes, the trade between Addis Ababa and Mekele changed from a situation of too little trade (high probability of regime 3) to too much trade (high probability of regime 2). Under these conditions it seems that traders made losses while the consumers in Mekele market might have gained from the wheat price decrease. In most of the cases, the Addis Ababa and Mekele market is observed to behave differently from other market pairs, which might be because of the roadblock charges and control on grain going to Tigray.

Prior to the policy changes, all the wheat market pairs considered are spatially inefficient most of the time. In 5 of 7 market pairs, the probability of spatial price differential greater than transfer cost is statistically significant at the 5% level. This is inconsistent with spatial market efficiency. On the other hand, the probability of spatial price differential less than transfer cost is greater than 80% for 2 of 7 wheat market pairs, where high frequency of wheat trade flow was also observed for these market pairs. This is also consistent with spatial market inefficiency, as grain traders would have lost money if they actually traded during this period. The structural change is significant only for Addis Ababa and Mekele market pair, where the nature of spatial inefficiency changed from high probability of making excessive profit to high probability of making losses. Thus, following the policy changes wheat markets are still spatially inefficient.

4.3 SUMMARY

Prior to the policy changes, both maize and wheat markets appear to be spatially inefficient most of the time. The likelihood ratio test shows that there is statistically significant joint structural change in trade regime probabilities in 3 of 7 maize market pairs and in 1 of 7 wheat market pairs as a result of the policy changes. However, the policy changes did not bring any significant improvement on the spatial efficiency of maize and wheat markets except in the case of Addis Ababa and Mekele where the spatial efficiency of the maize market improved after the policy changes, and in the case of Addis Ababa and Dire Dawa where the spatial market efficiency deteriorated for the maize market following the policy changes. Thus, maize and wheat markets are also spatially inefficient for most of the time after the policy changes.

However, it is observed that the nature of spatial inefficiency is different for maize and wheat markets. In the case of maize, spatial inefficiency is mostly due to the fact that there is high frequency of grain flow while there is high probability of spatial price differential less than grain transfer cost. In this case, if the grain traders are actually trading they are making losses. In the case of wheat the spatial market inefficiency is mostly due to high probability of spatial price differential greater than transfer cost. This is consistent with spatial market inefficiency whether or not there is trade, but indicates too little trade is occurring rather than too much.

The fact that the nature of spatial market inefficiency observed for maize and wheat is different implies that the two commodities probably require a different policy response in order to improve spatial market efficiency. One of the possible reasons for the observed differences in the nature of spatial inefficiency between maize and wheat might be due to the difference in their market structures. The geographic locations of surplus maize and surplus wheat producing regions are different. Maize is produced mainly in the western regions of Ethiopia while wheat is grown in central regions of the country. The marketing infrastructure, particularly the road network, is relatively more developed in the central regions. Among other things, this might have attracted investment in storage and other marketing facilities in the wheat areas, which encouraged the development of relatively larger wholesale grain traders, which can influence wheat prices. The analysis of the structure and conduct of wholesale grain trade in Ethiopia by Dessalegn et al. (1998) also indicates that the wheat markets are more concentrated. On the other hand, the marketing infrastructure in the western region is less developed and the grain traders are expected to be smaller sized and maybe numerous compared to the central regions.

Finally, as with empirical studies of spatial market efficiency, it is important to keep in mind that data and estimation methods have inherent weaknesses. For example, the results are sensitive to the accuracy of transfer cost estimated from the survey and and the distributional assumptions made. Therefore it is always important to interpret the empirical results with caution and think critically about the implications of the results for the design and implementation of public policy.

Table 4.1 Minimum Observed Months of Trade Flows for Selected Maize and Wheat Market Pairs

	1996:08 to 1999:09		1999:10 to 2002:08		1996:08 to 2002:08	
Market pairs	Maize	Wheat	Maize	Wheat	Maize	Wheat
Addis & Bale Robe	--	23(89)	--	34(97)	--	57(93)
Addis & Dessie	22(85)*	26(100)	35(100)	31(89)	57(93)	57(93)
Addis & Dire Dawa	15(58)	26(100)	13(37)	35(100)	28(46)	61(100)
Addis & Hosanna	--	26(100)	--	35(100)	--	61(100)
Addis & Jimma	26(100)	--	35(100)	--	61(100)	--
Addis & Mekele	18(69)	24(92)	4(11)	23(66)	22(36)	47(77)
Addis & Wollega	25(96)	--	35(100)	--	60(98)	--
Dire Dawa & Nazareth	4(15)	26(100)	0(0)	35(100)	4(7)	61(100)
Dire Dawa & Shashamane	23(89)	10(39)	35(100)	34(97)	58(95)	44(72)

Note: *The maximum possible number of monthly observations for the period before and after the policy change is 26 and 35, respectively and figures in parenthesis are percentages of months with trade flows.

Table 4.2 Conditional Maximum Likelihood Estimates of EPBM for the Maize Markets (1996:08 to 2002:08)

	Market pairs						
EPBM Parameters	Jimma & Addis	Nekempte & Addis	Addis & Dessie	Addis & Dire Dawa	Addis & Mekele	Nazareth & Dire Dawa	Shashamane & Dire Dawa
Regime probabilities							
λ_1	0.001[a]	0.236	0.001[a]	0.326[c]	0.001[a]	0.201	0.339
λ_2	0.872[a]	0.763[a]	0.889[a]	0.673[a]	0.315[a]	0.798[a]	0.660[c]
λ_3	0.127	0.001[a]	0.110	0.001[a]	0.684[a]	0.001[a]	0.001
Structural changes							
δ_1	+0.997[a]	+0.133	0.000	-0.325[c]	+0.662[b]	+0.588[b]	-0.196
δ_2	-0.871[a]	-0.762[a]	+0.110	-0.233	+0.022	-0.796[a]	+0.009
δ_3	-0.126	+0.629[a]	-0.110	+0.558[a]	-0.684[a]	+0.208	+0.187[c]
Standard deviations							
σ_e	5.181[a]	4.854[a]	2.498[a]	4.456[a]	6.475[a]	10.100[a]	7.265[a]
σ_u	3.159[c]	8.945[a]	5.706[a]	15.764[a]	10.658[a]	8.572[b]	15.112[a]
σ_v	6.512	10.540[a]	10.007[b]	16.961[a]	18.621[a]	30.651[a]	31.534[a]
Transition period (ℓ)	0	6	35	0	5	0	0
Log likelihood							
Restricted	-231.612	-259.456	-224.630	-297.220	-293.538	-292.277	-296.697
Unrestricted	-230.150	-251.988	-223.589	-289.548	-285.519	-289.469	-292.484
LR Test							
$\chi^2(3)$ Statistics	2.90	14.936[a]	2.08	15.344[a]	16.038[a]	5.618	1.74
Observations	73	73	73	73	73	73	72

Note: Trade is more than 99% uni-directional, the first and second market in the list of market pairs being the source and destination market, respectively. Note also that [a], [b] and [c] indicate statistical significance at 1%, 5%, 10%, respectively. The possible values of ℓ range from 0 to 35.

Table 4.3 Conditional Maximum Likelihood Estimates of EPBM for the Wheat Markets (1996:08 to 2002:08)

EPBM Parameters	Market pairs: Bale & Addis	Hosanna & Addis	Addis & Dessie	Addis & Dire Dawa	Addis & Mekele	Nazareth & Dire Dawa	Shashamane & Dire Dawa
Regime probabilities							
λ_1	0.001 [a]	0.001 [a]	0.001 [a]	0.001 [a]	0.001 [a]	0.001 [a]	0.001 [a]
λ_2	0.001 [a]	0.001 [a]	0.998 [a]	0.001 [a]	0.001 [a]	0.811 [a]	0.001 [a]
λ_3	0.998 [a]	0.998 [a]	0.001 [a]	0.998 [a]	0.998 [a]	0.188	0.998 [a]
Structural changes							
δ_1	0.000	0.000	0.000	0.000	0.000	+0.998 [a]	0.000
δ_2	0.000	+0.109	0.000	0.000	+0.711 [a]	-0.811 [a]	0.000
δ_3	0.000	-0.109	0.000	0.000	-0.711 [a]	-0.187	0.000
Standard deviations							
σ_e	6.234 [a]	2.583 [b]	9.886 [a]	16.465 [a]	11.212 [a]	15.017 [a]	17.583 [a]
σ_u	0.001 [a]	2.275	0.452	0.001 [a]	12.620 [a]	11.917 [b]	0.001 [a]
σ_v	19.843 [a]	19.214 [a]	23.491	2.231	27.393 [a]	23.096 [b]	10.321
Transition period (ℓ)	0	0	3	2	0	4	0
Log likelihood							
Restricted	-289.931	-279.268	-71.106	-308.244	-33.041	-315.703	-312.793
Unrestricted	-289.931	-278.385	-71.106	-308.244	-20.799	-313.480	-312.753
LR Test							
$\chi^2(3)$ Statistics	0.000	1.766	0.000	0.000	24.484 [a]	4.446	7.818
Observations	73	73	73	73	73	73	72

Note: Trade is more than 99% uni-directional, the first and second market in the list of market pairs being the source and destination market, respectively. Note also that [a], [b] and [c] indicate statistical significance at 1%, 5%, 10%, respectively. The possible values of ℓ range from 0 to 35.

Figure 4.1 Magnitude of Losses and Gains from Inefficient Trade for Maize

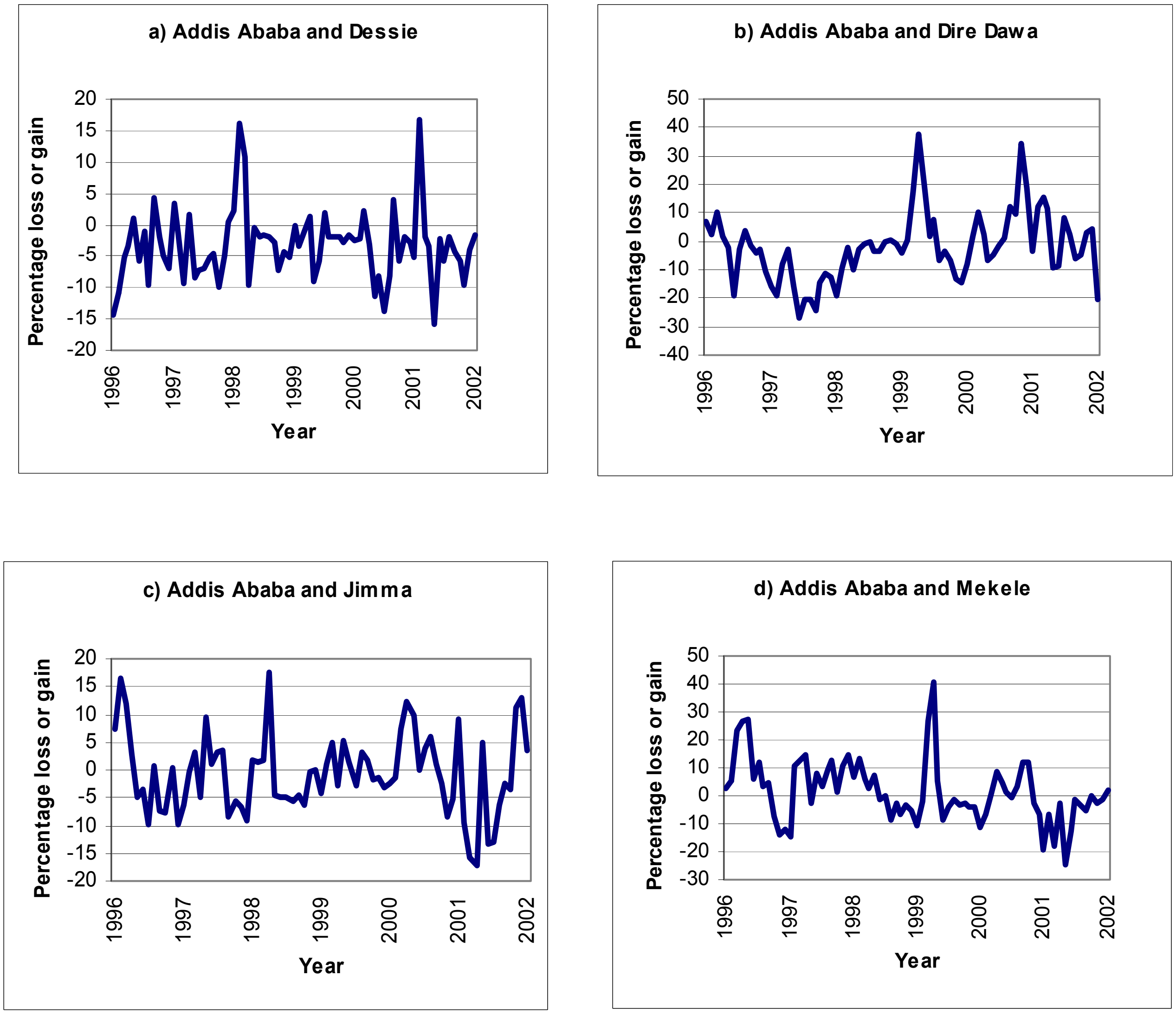
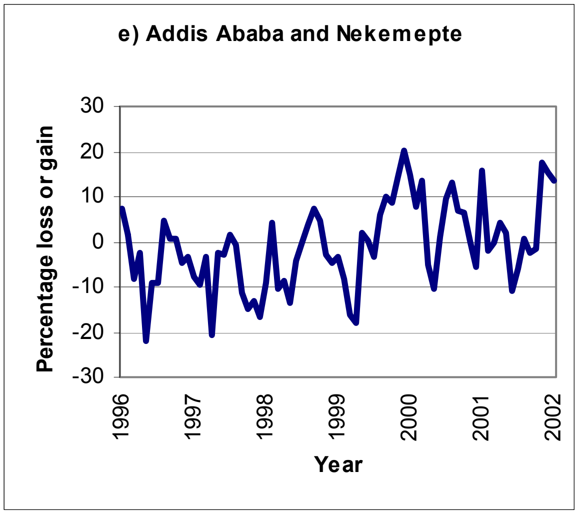
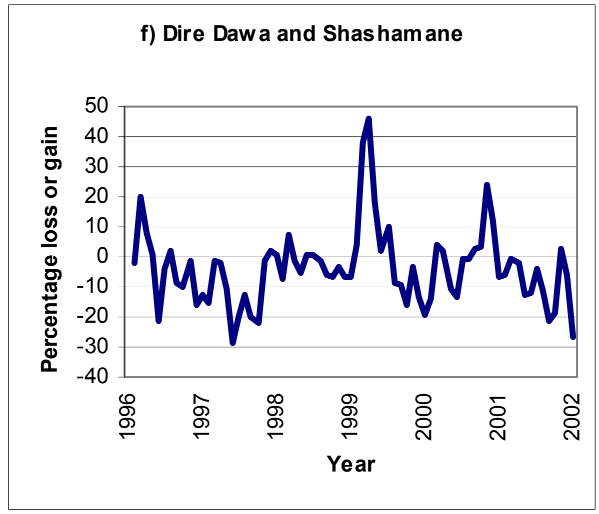


Figure 4.1 (Continued)





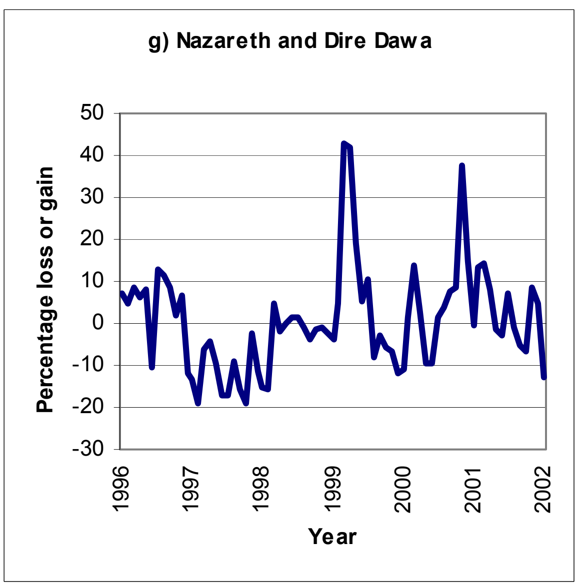


Figure 4.2 Magnitude of Losses and Gains from Inefficient Trade for Wheat

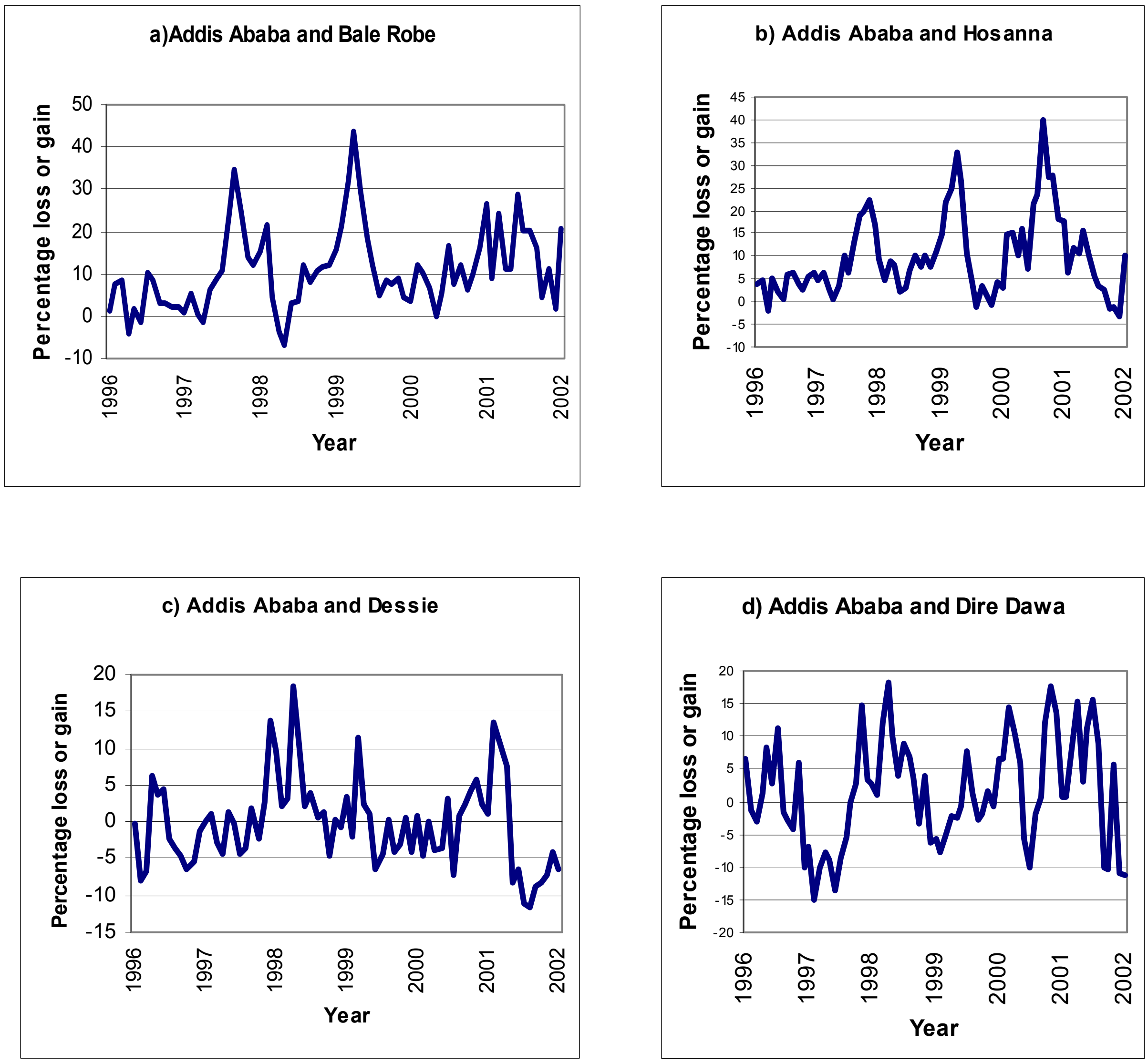
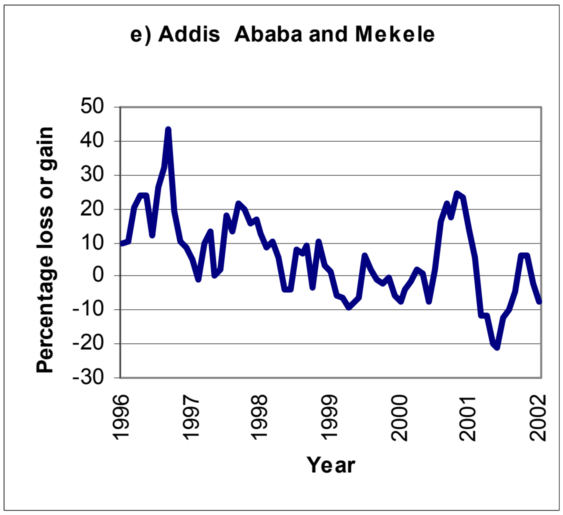
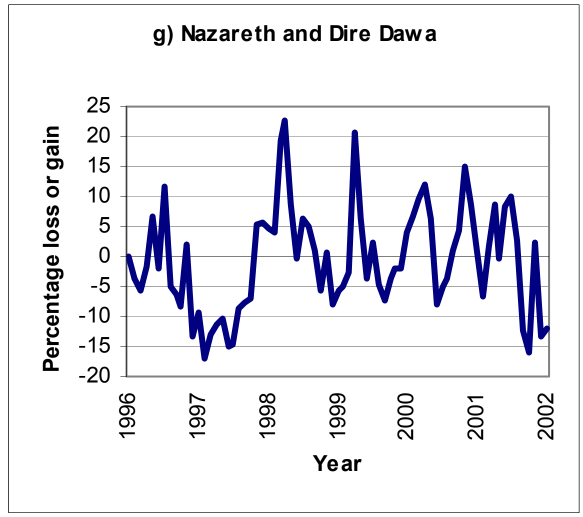
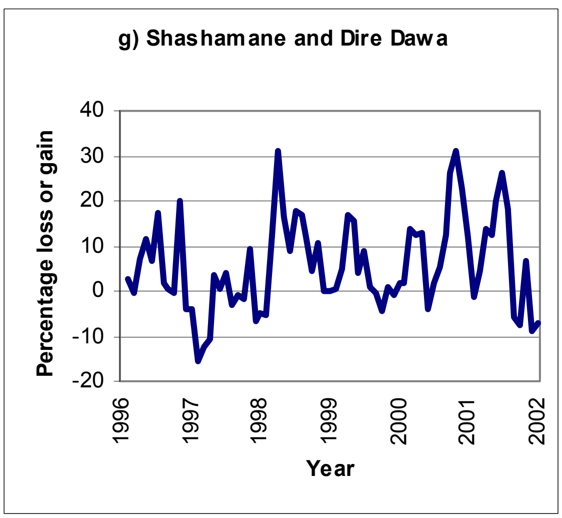


Figure 4.2 (Continued)







5. CONCLUSIONS AND POLICY IMPLICATIONS

In recent years, the Ethiopian government has embarked on various market reform measures aimed at improving grain market performance. Research is needed to improve understanding of the operation of grain markets, and the effects of policy changes on grain market development. The conventional methods which have been used to study spatial market efficiency and/or spatial market integration depend on an assessment of the co-movement of price series, or the long-run relationship between prices. These methods assume stationary spatial marketing margins, stationary transfer costs, and/or that markets are linked by a constant trade pattern (uni-directional and continuous). However, these assumptions are often violated and so the resulting tests of market integration may be misleading.

The standard parity bounds model (PBM) represents one of the recent developments, which attempts to overcome some of the weaknesses of the conventional methods. The PBM allows for transfer costs and explicitly incorporates spatial arbitrage conditions in the test of spatial market efficiency. However, in the context of on-going market reform and policy changes in developing countries, the standard PBM needs further improvements in order to properly assess the effect of policy changes on spatial market efficiency. This is because the standard PBM has been used mostly to analyze spatial market efficiency within a given, constant policy regime. In cases where it has been used to analyze the effects of policy changes on spatial market efficiency, the effect of policy changes is assumed to be instantaneous. However, the PBM is mis-specified and the results and policy implications might be misleading if the actual effect of policy changes on spatial market efficiency is gradual and moves through a transition period, as might be expected in many cases.

The EPBM is a stochastic gradual switching regression model with three trade regimes. The EPBM improves the standard parity bounds model in two ways. First, the EPBM allows a better understanding of the nature of transition from old to new policy regimes, including whether it is gradual or instant. If it is gradual, the model also allows estimation of the length of time required for the full effects of policy changes to be realized. Second, it allows formal statistical tests to be undertaken for structural change in the probabilities of different trade regimes due to policy changes.

The EPBM is estimated using maximum likelihood and utilizes data on observed wholesale grain prices for several regional markets in Ethiopia and grain transfer costs. One of the problems with implementing the PBM empirically is that time series data on transfer costs are rarely available, particularly in developing countries like Ethiopia. As a result, most empirical PBM studies have assumed transfer costs are constant over time for a given policy regime. However, this assumption is very restrictive, particularly when the PBM is used to analyze the effects of policy changes. This is because if transfer costs are assumed to be constant when they actually fluctuate considerably over time then the PBM may misinterpret spatial price deviations as evidence of inefficiency when they are actually just a rational response to changes in transfer costs. Thus, there is a need to go beyond the constant transfer cost assumption and find better ways of using data that are available to construct more appropriate inferences about historical movements in transfer costs. This paper also discusses a technique for parametric estimation of time variant grain transfer costs based on an initial computation of grain transfer costs using cross-sectional surveys of grain traders in Ethiopia and time series truck shipment freight rate data.

The EPBM is applied to examine the effects of grain price marketing policy changes implemented in October 1999 on spatial efficiency of maize and wheat markets in Ethiopia. The results indicate that there is considerable spatial inefficiency in maize and wheat markets in Ethiopia both before and after the policy changes. In most of the cases, the effect of policy changes on spatial grain market efficiency is not statistically significant. However, in cases where significant structural change did occur some markets adjusted to the policy changes gradually while others adjusted instantaneously. Thus, an instantaneous response to marketing policy changes cannot be taken for granted and needs to be tested empirically.

The spatial inefficiency of maize and wheat markets indicates that resources are being misallocated in transferring maize and wheat from surplus producing regions to grain deficit regions of Ethiopia. There are several possible explanations of these results. First, maize and wheat markets are characterized by periodic localized gluts and shortages which can undermine the welfare of producers, grain traders and consumers by increasing price instability. Second, the marketing system lacks the capacity to provide timely and accurate price signals needed for efficient allocation of resources. Third, the marketing system does not provide adequate incentives for producers to adopt new technologies. Fourth, the high probability of making losses also decreases private sector participation in grain marketing.

Finally, as with all empirical studies of spatial market efficiency, it is important to keep in mind that data and estimation methods have inherent weaknesses. For example, the results are sensitive to the accuracy of transfer costs estimated from the cross-sectional survey of grain traders and time series truck shipment freight rate data. PBM results are also well known to be highly sensitive to the distributional assumptions made for the estimation method. Therefore it is always important to interpret the empirical results with caution and think critically about the implications of the results for the design and implementation of public policy. The other limitation of this study is that it only assesses the degree of spatial efficiency of grain markets and does not address the questions as to why the markets are not spatially efficient. Therefore, in order to provide relevant policy recommendations, it is important to identify the exact causes of spatial inefficiencies using available research results and through conducting new research.

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