Measuring the Impact of Road Rehabilitation on Spatial Market Efficiency in Maize Markets in Mozambique

Xavier Cirera and Channing Arndt

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Contact:
Xavier Cirera
National Directorate of Studies and Policy Analysis
Ministry of Planning and Development
Av. Ahmed Sekou Touré nº 21, 7º andar
Maputo, Moçambique
Tel: (+258) 2 1 499442
Fax: (+258) 2 1 497663
Web: www.mpd.gov.mz
Email: <xcirera@mpdgov.mz>

Channing Arndt
National Directorate of Studies and Policy Analysis
Ministry of Planning and Development
and Purdue University
carndt@gmail.com

Abstract

This paper applies an extended version of the Parity Bounds Model (PBM) to the analysis of the impact of road rehabilitation on spatial market efficiency in maize markets in Mozambique. We apply different sets of estimates for transaction costs in order to improve the robustness of the results. The main finding is that maize markets tend to be segmented due to high transport costs most of the time. The impact of road rehabilitation seems to be small and it is not statistically significant for most market pairs.

1. Introduction

Spatial market efficiency is a key element for policy transmission and effectiveness. Well functioning markets are crucial to ensure the desired impact of different economic policies, such as macroeconomic or trade policy. Spatially segmented markets isolate economic agents and households across space, limiting the transmission of price incentives and the resulting positive welfare impact in terms of lower prices and increased product availability.

This paper attempts to measure the extent of spatial efficiency in Mozambique. Traditionally, Mozambican provinces have tended to be poorly integrated due to high transport costs (Tostao and Brorsen, 2002, Arndt and Penzhorn, 2002). Nevertheless, the country has experienced significant liberalisation and high growth rates, especially since the end of the war in 1992, increasing the number of participants in trading activities. Furthermore, very substantial investments in roads and road rehabilitation have occurred, particularly since the late 1990s. This paper examines the impact of road rehabilitation on spatial efficiency.

In order to do so, we use differences in maize prices as an indicator of market arbitrage, following an extension of the Parity Bounds Model (PBM) methodology similar to Park et al. (2002) or Negassa, Myers and Gabre-Madhin (2003) The advantage of using locally produced white maize as the reference good is that it is a homogenous with widespread demand and with similar quality characteristics. These characteristics permit comparison across markets in the country.

The article is organised as follows. The next section defines the concept of spatial market efficiency. Section 3 describes the existing methodologies to analyse spatial efficiency. Section 4 describes the situation of the maize sector in Mozambique. Section 5 analyses the impact of road rehabilitation on spatial arbitrage on pairs of provincial markets. The final section concludes.

2. Theory on Spatial Market Integration and Efficiency

Markets gather together demand and supply across actors that are located in different points of geographical space. In well integrated markets, regions with excess supply are able to transfer production to regions with excess demand, responding to price signals.

Market integration is at the heart of welfare analysis in economics. In the international domain, the impact of monetary, exchange rate or trade policy depends on how well markets are integrated and whether prices tend to equalise (i.e., the "impossible trinity" in monetary policy, the law of one price or the Stolper-Samuelson theorem). In the national domain, any macroeconomic policy (monetary, fiscal, trade, infrastructure or technology) is mainly transmitted by changes in relative prices. If markets of the same country are segmented with limited price transmission, economic policy becomes less effective.

As an example, consider the case of trade reform. In the short run, a change in relative prices of tradable to non-tradable goods will create adjustment in demand and supply of these goods. However, the relative price change is observed at the border. The implications of trade reform depend on the degree of market integration. In the case of segmented markets, trade reform may alter consumer behaviour and foster specialisation in firms located near the border, while leaving rural areas, often more populated, largely unaffected.

Integration has been traditionally associated with the "Walrasian" concept of transfer of excess demand from one market to another via trade flows, price shocks or both. Under this tradability view, trade flows are sufficient to signal spatial market integration, but do not necessarily imply price equalization, which is consistent with inefficient Pareto distributions (Barrett, 2005). A second approach, based on Baumol's work on contestable markets, focuses instead on the full exploitation of arbitrage rents and competitive markets. Under this second approach to spatial market integration, two markets are integrated when there are zero marginal profits to arbitrage, leaving agents indifferent about trading, and therefore, reaching a competitive equilibrium and a Pareto efficient distribution (Barrett and Li, 2002).

These approaches to market integration are related but are not identical. Under the first approach, trade is sufficient but not necessary for market integration. Two markets can be integrated by belonging to a network or by having a state trading institution that fixes prices adjusted to regional or national shocks. In these cases, price shocks are transmitted even in the absence of trade. On the other hand, under the spatial efficiency approach, efficiency can be achieved without observing trade between two locations if there are no marginal profits to arbitrage. This is especially the case in the presence of high transactions costs.

The existing literature has tended to focus more on the spatial efficiency approach to market integration. This is due in part to the theoretical reasons suggested above (Pareto efficiency, competitive markets and the fact that observing trade is not a sufficient condition for efficiency). Practical reasons also play a role as price data across space is tends to be more readily available than trade flow data between market pairs. This paper follows the spatial efficiency approach to market integration described above.

The "Enke-Samuelson-Takayama-Judge" Model

The base of spatial equilibrium analysis is the Enke-Samuelson-Takayama-Judge model. The main prediction of this model is that the price differential between two markets for an identical good depends on the size of transaction costs between the two locations.

Assume that two regions of a country could engage in trade, and the price in autarky of good *a* in markets *i* and *j* depends on a demand/supply shifter α and a random component *ε* specific for every market at time *t*. Transaction costs of good *a* between market *i* and *j* T_{jit}, depends on a time varying transaction cost τ_{jit} and a random component ς_{jit}.

$$P_{it} = \alpha_{it} + \varepsilon_{it} \quad (1)$$

$$P_{jt} = \alpha_{jt} + \varepsilon_{jt} \quad (2)$$

$$T_{jit} = \tau_{jit} + \varsigma_{jit} \quad (3)$$

In this model, there are multiple regimes expressed by the following three equations (where $\Delta P_{ijt} = P_{it} - P_{jt}$):

$$\Delta P_{ijt} = T_{jit} \text{ Spatially Efficient Market} \quad (4)$$

$$\Delta P_{ijt} < T_{jit} \text{ Spatially Segmented Competitive Market} \quad (5)$$

$$\Delta P_{ijt} > T_{jit} \text{ Spatially Inefficient Market} \quad (6)$$

In *(4)* there is no room for arbitrage and the price differential equals transaction costs. This is equivalent to the law of one price, profits are maximized and there is competitive equilibrium, with or without the presence of trade flows. In the second disequilibrium situation *(5)*, markets are competitive but segmented, since high transaction costs make trade and arbitrage unprofitable. Prices may be uncorrelated within a band of high transaction costs that make arbitrage profits negative. Finally, at the third disequilibrium situation *(6)*, price differentials are larger than transaction costs, which implies that there unexploited arbitrage rents. This may be due to lack of information, barriers to entry, market power or trade quotas. In this case, some trade may or may not occur; however, if trade occurs, under the tradability approach, there is some degree of integration between markets, but they are not competitive. Under the efficiency approach to market integration, however, disequilibrium in *(6)*, spatial inefficiency, is considered as evidence of lack of integration (Baulch, 1997).

3. Approaches for Testing Market Efficiency

Spatial market efficiency has been mainly analysed by looking at the behaviour of prices and transaction costs. This is to determine whether price differentials tend to converge and whether potential quasi-rents tend to be arbitraged away. The following methodologies have been used (in rough chronological order) for analysing spatial arbitrage or spatial price analysis (see Fackler and Goodwin, 2002, for a detailed overview).

3.1 Correlation Measures

Correlation measures for both, prices and price differences, were first used to look at the behaviour of prices of the same good for market pairs. The advantage of correlation measures is that they are very simple measures to compute. Nevertheless, they present significant weaknesses. The main and usual caveat is that correlation does not imply causality. For example, factors not related to integration, such as general increases in the levels of prices (e.g., inflation), may explain co-movements of prices or price changes in two market pairs. Correlation measures also typically assume instantaneous adjustment of prices, which can lead to underestimation of integration when adjustment needs one or several periods to occur. Finally, when markets are in autarky (the regime described in equation (5)), there is no reason for price movements to be correlated; hence the correlation measure alone cannot shed light on the issue of market efficiency.

3.2 Delgado's Variance Decomposition

This method uses variance decomposition to eliminate the presence of common trends and seasonality from all price series. It estimates transport and transaction costs for a season and assume that they are constant during that season. Then, it compares price spreads between two markets of the de-trended series, with transport and transaction costs for the period (Negassa, Myers and Gabre-Madhin, 2003). Equality of prices spreads with transaction costs would indicate market integration. Like simple correlations, a problem with this method is the use of contemporaneous relationships, and therefore the omission of price dynamics.

3.3 Ravallion's Method

Ravallion (1986) proposes a method of testing integration that allows distinguishing between short-run market integration, long-run market integration and market segmentation. Ravallion proposes the estimation of the following system of equations:

$$\Delta P_{it} = \alpha_0 + \alpha_1 p_{jt} + \alpha_2 p_{it-1} + \alpha_3 \Delta p_{jt-1} + \alpha_4 S_{it} + \alpha_5 D_{it} + \varepsilon_i \quad (7)$$
$$\Delta P_{jt} = \beta_0 + \beta_1 p_{it} + \beta_2 p_{jt-1} + \beta_3 \Delta p_{it-1} + \beta_4 S_{jt} + \beta_5 D_{jt} + u_t \quad (8)$$

In this system of equations, price differences are regressed using three-stage least squares on other market contemporaneous prices and lagged price differences, own lagged price and variables that impact supply and demand such as income or technology. This allows testing the following hypotheses:

i) Markets *i* and *j* are segmented H_0: $\alpha_1 + \beta_1 + \alpha_3 + \beta_3 = 0$
ii) Markets *i* and *j* jointly integrated in the short-run H_0: $\alpha_0 = \beta_1 = 1$ *and* $\alpha_2 = \alpha_3 = \beta_2 = \beta_3$
iii) Markets *i* and *j* jointly integrated in the long-run H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \beta_1 = \beta_2 = \beta_3 = 1$

Ravallion's approach also has several weaknesses. This approach is based on a radial structure from a group of local markets to a single central market, ruling out the possibility of flows reversals. It also assumes constant transaction costs.

3.4 Cointegration Analysis

In the presence of unit roots, OLS estimation of price relationships between markets becomes spurious. Cointegration techniques surmount this problem and permit the estimation of short-run relationships between pairs of prices in the form of cointegrating vectors. This methodology also allows the estimation of the speed of adjustment between prices in the short and long-run.

Despite the advantages, there still remain several problems with cointegration methods in spatial price analysis. First, the existence of a cointegrating relationship does not necessarily imply market integration. Like simple correlation analysis, the relationship could be the result of cointegrated macroeconomic or demand/supply shocks in the markets under study (Negassa, Myers and Gabre-Madhin, 2003). It also implies unidirectional trade flows and assumes stationary transaction costs.

3.5 Threshold Models

Obstfeld and Taylor (1997) test the law of one price using a threshold methodology based on Hoeckcher´s notion of "commodity points". The idea is that there exists a "neutral band" or "band of inaction" where high transaction costs imply that arbitrage does not occur because it is not expected to yield any positive gains. Once above a certain threshold, arbitrage becomes profitable and prices tend to equalize. Therefore, any analysis that does not consider these thresholds will tend to underestimate the extent of integration.

Two main techniques have been used for estimating these threshold models

- *Threshold cointegration*, where autoregressive models are estimated, TAR and M-TAR, estimating first the threshold of the neutral bands (Abdulai, 2000). This also allows estimation of the speed of convergence of prices
- Non-parametric estimation, which allows estimating transaction cost bands without assuming any functional form (Serra, Goodwin and Mancusso, 2004). This technique tends to predict larger degrees of integration than TAR models.

An advantage of threshold models is that they do not need transaction costs data for estimating the "neutral band"; however, they assume constant transaction costs. In addition, these models continue assuming unidirectional trade flows and threshold cointegration techniques tend to be highly parameterised.

3.6 Parity Bound Model (PBM)

The PBM is also a model based on the importance of transaction costs when analysing spatial price efficiency. This methodology estimates by maximum likelihood a switching regression model for the three regimes predicted by the ESTJ model described above, namely: efficiency, segmented efficiency and inefficiency (represented by equations (4), (5) and (6)). This model accommodates time varying transaction costs, trade reversals, and the situation of autarky (Sexton, Kling and Karman, 1991, Baulch, 1997). Furthermore, the fact that it allows the estimation of probabilities for every regime implies the possibility of measuring the extent of spatial market efficiency.

This approach has still several weaknesses (Negassa, Myers and Gabre-Madhin, 2003). First, it ignores the time series properties of price and transaction cost data. Second, the distributional assumptions of the variables are not based on economic theory and the results of the estimation depend critically on these assumptions. Third, short-term deviations from equilibrium that are the result of rational lagged adjustment are treated as inefficiency.

Despite these caveats, the PBM is the main methodology that has been used for spatial price analysis. Monte Carlo experiments have been designed to correct for potential weaknesses related to distributional assumptions. The PBM methodology has been extended by Barrett and Li (2005) to add trade flows and improve market integration analysis. Moser, Barrett and Minten (2005) also extend this methodology to the study of integration in time and form for the case of rice in Madagascar. Finally, the PBM model allows estimation of transaction costs endogenously using price data (Park et al. 2002).

Another important weakness of the original PBM formulation is the lack of dynamics; spatial market efficiency is estimated for a single period. However, the evolution of efficiency over time and the influence of policies in this evolution are central to the objective of this paper. Our approach modifies the original PBM model in order to analyse these issues. Before presenting the exact form of the modified PBM model as well as the data employed for analysis, maize markets in Mozambique are discussed.

4. Maize Markets and Spatial Market Efficiency in Mozambique

The production of maize in Mozambique is not evenly distributed across the country. Provinces in the central and northern region often produce maize surpluses, while provinces in the south are net consumers. Lack of market maize integration at the national level is demonstrated by the fact that southern provinces import maize, mainly from South Africa, while northern and some central provinces export maize, mainly to Malawi[1].

4.1 The Maize Sector in Mozambique

State involvement in maize marketing used to be significant. The maize marketing systems was characterized by a parastatal monopsony, the *Instituto dos Cereais de Moçambique* (ICM) (see Box 1 for a detailed explanation of state intervention in maize commercialization in Mozambique). After independence, the ICM was re-established with the mandate of becoming the buyer of the last resort, purchasing maize from farmers in remote areas where there was no private sector presence or areas where lack of infrastructure made commercialization very difficult. The ICM carry out its last intervention (see Table 1) in 1999.

Since 1996 some large private traders started operating in maize markets and commercialize maize in central and northern regions. Commercialization is currently dominated by informal traders and these few commercial traders. The World Food Programme (2005) suggests that overall informal traders commercialize larger volumes than formal traders. Informal traders are normally individuals, often women, specialised in selling maize, who travel from urban areas to production centres and buy small quantities of maize. They transport maize to market areas using returning empty trucks and other forms of transport. On the other hand, formal traders tend to be larger and engaged in selling more than one product. They also tend to buy maize for export or for sale to larger buyers, such as the WFP. These larger traders tend to use the ICM warehouse facilities and have their own transport equipment.

[1] Informal exports to Malawi were estimated in around 71 thousand tones between the period July 2004 and march 2005 (WFP, 2005)

Production of maize occurs mainly on small family plots. According to official figures, production has grown relatively slowly since 1996 (see Table 2), and remained stagnant or decreased in some years, 1999 to 2003, due mainly to climate shocks. In 2004, maize production has grown considerably. Maize markets, especially in southern provinces and some remotes areas in the centre and north, are characterised by maize shortages. WFP (2005) establishes that the maize needs for their programmes are around 5% of total production in 2005/2006. Most of this maize required by WFP has to be imported, since local suppliers do not comply with WFP price and quality standards. In addition, WFP purchases in certain areas could create further pressure on prices and food security.

Neither the ICM nor private traders offer extension services. Only some NGOs have offered extension services and some improved seeds were introduced in 1998. However these services only target a very small number of farmers in specific areas.

Maize production shortages increased significantly nominal and real prices of maize in 2000 (See Figure 1). From 2002, prices have remained relatively stable, increasing in nominal terms in consumption areas.

This could have implications in terms of spatial arbitrage. High nominal prices imply that larger traders have reduced the purchase of maize and substituted with other products, such as beans or sorghum, especially since 2004 (WFP, 2005). As a result, there is an increase in the share of informal commercialization that maybe affecting spatial arbitrage. Informal traders are more sensitive to transport costs due to their lack of transport capacity. Finally, competition may have decreased in maize markets.

4.2. Transport Infrastructure and Transport Costs

At first sight, spatial markets in Mozambique seem to be segmented by poor infrastructure. Regarding road infrastructure, 53% of roads are non-paved tertiary roads that connect districts. Of the remaining, 16% are primary roads and 31% are secondary roads. These have been progressively rehabilitated in the last five years (MIC, 2001) though road conditions remain far from perfect. In addition, other problems identified are low density of roads and security problems for drivers

(Jacobs, 2005). This has implications in terms of high costs of road transport, especially in areas with segmented infrastructure such as Nampula or Zambezia.

Railway transport is limited to the three development corridors, connecting ports to neighbouring countries (South from Maputo to South Africa, Centre from Beira to Malawi and North from Nacala to Malawi). Despite concentrate 77% of the transport of goods (MIC, 2001), railway transport fares are above those in neighbouring countries, and the railway network does not allow to connect spatial markets from North to South. Other problems include lack of reliability of services, and associated with this, unbalanced trade flows that imply empty containers on return trips (Jacobs, 2005).

On the other hand, maritime transport, a seemingly natural and potentially cheaper way of transporting goods from North to South, experiences significant problems. There are three main ports, Maputo, Beira and Nacala; and three secondary ports, Inhambane, Quelimane and Pemba. Only two of the primary ports have infrastructure and services able to absorb large vessels. Beira´s port is experiencing problems due to lack of dredging that prevents the entrance of large vessels. Maritime transport is also more expensive than in neighbouring countries, with the added problem of lack of vessels availability and low frequency of services between main Mozambican ports[2] (MIC, 2001).

The state of transport infrastructure suggests that markets are likely to be segmented and therefore, it should be expected that recent investments in roads and other infrastructure may have a direct impact on enhancing spatial market efficiency and integration.

4.3 Evidence on Spatial Market Efficiency in Maize Markets in Mozambique

There are several studies on spatial efficiency in maize markets in Mozambique. A detailed study by Donovan (1996) found significant price linkages between maize markets in Maputo and Chimoio. For the same market pair, Arndt and Penzhorn

[2] Very often vessels do not leave port until they are at full capacity.

(2002) estimate a PBM and found that the probability of spatial efficiency is around 75%, while the probability of spatial inefficiency is around 22%.

Tostao and Brorsen (2002) estimate the PBM for 13 market pairs. The authors find that markets in central Mozambique are spatially very efficient (94% of the time) followed by markets in the south (55% of the time), and that spatial arbitrage between Central and Southern markets is efficient more than 90% of the time. Price spreads between northern markets and the centre and south region are below transaction costs most of the time. Thus, according to these authors markets are mostly spatially efficient. Nevertheless, high transport costs impede integration.

Abdula (2005) analyses integration and adjustment for six pairs of retail markets and also between wholesale and retail prices in the same and different markets in the South and Central region. The author uses an approach based on cointegration techniques and Granger causality tests. The main result is that integration is relatively weak, price shocks are not fully transmitted and there is on average two weeks delay in the transmission of shocks

Consequently, existing evidence seems to suggest that maize markets tend to be spatially efficient, however, integration is still very limited due to high transaction costs, especially between net producers northern provinces and net consumer southern provinces.

5. Methodology and Data

A large amount of investment has been oriented towards significant road rehabilitation. As suggested by existing evidence on spatial market efficiency in Mozambique, spatial efficiency is seriously constrained by very high transport costs. Thus, we should expect that substantial road rehabilitation could impact positively the likelihood of becoming more efficient.

5.1 Methodology: extended PBM

The methodology used in this paper is based on the methodology proposed by Park et al. (2002) and Negassa, Myers and Gabre-Madhin (2003), extending the traditional PBM methodology in order to capture policy impacts on spatial price efficiency.

As suggested in section 3, spatial market integration can be characterised by the following three regimes (corresponding to equations *(4)* to *(6)*):

$$|P_{it}-P_{jt}| = \delta_{ijt} + e_t \qquad (9)$$

$$|P_{it}-P_{jt}| = \delta_{ijt} + e_t - u_t \qquad (10)$$

$$|P_{it}-P_{jt}| = \delta_{ijt} + e_t + v_t \qquad (11)$$

Regime I in equation *(9)* represents spatially efficient markets. This regime is at the parity bounds. Price differences, between *i* and *j*, equal transaction costs in period *t*, δ_{ijt}, and an error term component, e_t iid Normal (0, σ_e^2), capturing unexplained variation at the parity bounds, normally associated to unexplained variations in transaction costs estimates. Regime II in *(10)* represents the autarky regime, when price differentials are below transaction costs, inside the parity bounds. The error term u_t can only be positive, semi-truncated positive, and measures by how much prices fall short of the parity bounds. Finally, Regime III in equation *(11)* represents spatially inefficient markets, where price differentials are above transaction costs. The semi-truncated positive error term v_t measures by how much price differences exceed transaction costs. The errors, u_t and v_t, are associated with demand and supply conditions respectively.

The PBM estimates the probability for a market pair of being in one of the three regimes, given data on prices differences and transaction costs estimates.[3] The main intuition is that we estimate for every period t the probability of being in the three regime bands: the parity bound, inside or above. These bands are determined by the variance of the error terms; σ_e^2 for regime I, $\sigma_e^2 + \sigma_u^2$ for regime II, and $\sigma_e^2 + \sigma_v^2$ for regime III (assuming the errors are uncorrelated).

[3] Transaction costs estimates can be estimated endogenously in the model.

In order to estimate the probability of being in one regime or another, we need to define the likelihood function in *(12) given* the f_{rt} density functions for every regime (equations *(13)* to *(15)*), where $\phi(\,)$ is the standard normal density function and $\Phi(\,)$ is the cumulative distribution function. Equation (16) is maximized in logarithm form and we obtain estimates of the parameter vector ϑ that contains σ_e, σ_u, σ_v, λ_{1t}, λ_{2t}, λ_{3t}, and, when estimated endogenously, transaction costs δ_{ijt}.

$$f_t(\rho_t \mid \vartheta) = \lambda_1 f_{1t}(\rho_t \mid \vartheta) + \lambda_2 f_{21t}(\rho_t \mid \vartheta) + (1-\lambda_1-\lambda_2) f_{3t}(\rho_t \mid \vartheta)$$
$$where \rho_t = \Delta p_{ijt} - \delta_{jit} \qquad (12)$$

$$f_{1t} = \frac{1}{\sigma_e}\phi\left[\frac{\|P_{it}-P_{jt}|-\delta_{jit}}{\sigma_e}\right] \qquad (13)$$

$$f_{2t} = \left[\frac{2}{(\sigma_e^2+\sigma_u^2)^{1/2}}\right]\phi\left[\frac{|P_{it}-P_{jt}|-\delta_{jit}}{(\sigma_e^2+\sigma_u^2)^{1/2}}\right]\left[1-\Phi\left[\frac{(|P_{it}-P_{jt}|-\delta_{jit})\dfrac{\sigma_u}{\sigma_e}}{(\sigma_e^2+\sigma_u^2)^{1/2}}\right]\right] \qquad (14)$$

$$f_{3t} = \left[\frac{2}{(\sigma_e^2+\sigma_v^2)^{1/2}}\right]\phi\left[\frac{|P_{it}-P_{jt}|-\delta_{jit}}{(\sigma_e^2+\sigma_v^2)^{1/2}}\right]\left[1-\Phi\left[\frac{(|P_{it}-P_{jt}|-\delta_{jit})\dfrac{\sigma_v}{\sigma_e}}{(\sigma_e^2+\sigma_v^2)^{1/2}}\right]\right] \qquad (15)$$

$$L = \prod_{t=1}^{T} \lambda_{1t} f_{1t} + \lambda_{2t} f_{2t} + (1-\lambda_{1t}-\lambda_{2t}) f_{3t} \quad (16)$$

In this paper, we modify slightly the PBM methodology above in line with Park et al. (2002). The methodology used here differs from the traditional PBM methodology, just by making the probabilities of belonging to any of the regimes dependent on time variant variables (see equations *(17)* and *(18)*). This extended PBM version estimates with the likelihood function equations (17) and (18) and obtain estimates for γ_0, γ_1, γ_2 and γ_3. Variable T_t is a time varying index variable that measures the introduction of some policy change, such as liberalization, that could have affected the probability of being in one regime or another. Thus, coefficients γ_1 and γ_3 measure the impact on the period probability associated to the introduction of the policy change.

$$\lambda_{1t} = \gamma_0 + \gamma_1 T_t \qquad (17)$$

$$\lambda_{2t} = \gamma_2 + \gamma_3 T_t \qquad (18)$$

5.2 Data

The primary source of data is the SIMA[4] database from the Ministry of Agriculture. This database provides mainly information on prices of several agriculture products in more than 30 markets spread around all the provinces of the country. The frequency is weekly since 1993, but there exists a significant amount of missing observations for some markets, especially at the beginning of the period. The absolute value of the price difference has been used as a measure of the price spread[5].

Price differences are deflated using the monthly CPI index available from the National Institute of Statistics (INE), and one of the series of transport costs estimates are extrapolated using a series of diesel prices also available from INE.

There are two main sources for transport cost observations. MIC (2001) carried out a survey collecting one period observation of transport costs for maize for some market pairs. In addition, the SIMA database has collected data on maize transport costs for some market pairs during some periods.

Finally, data on road rehabilitation, number of kilometres rehabilitated and date when road works were completed was gathered from the *Administração Nacional de Estradas* (ANE).

5.3 The impact of road rehabilitation on spatial arbitrage

The road network was seriously damaged by the war. In addition, the war prevented, for more than a decade, any substantial investment in rehabilitation, maintenance and new road construction. The inadequacy of the road network makes transport along the

[4] *Sistema Informação de Mercados*
[5] It was not possible to apply logs to the price differentials since the prices of the two markets were identical for some periods for all pair of markets.

2,500 kilometres distance from North to South of the country extremely costly, increasing the likelihood of market segmentation.

Since the war ended in 1992, and especially from 2000, there has been a significant increase in road rehabilitation (see Table 3). Furthermore, there is currently in place significant road rehabilitation programmes, mainly concentrated in the rehabilitation of the road EN1 that crosses the country from North to South. This is expected to enhance significantly markets integration across the country.

We expect road rehabilitation to impact spatial arbitrage via two different channels. The first and main channel is by lowering transport costs, and therefore transaction costs. Road improvement reduces the hazards and time length of road transport and therefore this should be translated into more transport services available and a reduction of transport costs. Second, road enhancement is likely to facilitate the entry to the market of more informal traders that have no transport capacity, increasing competition and arbitrage, reducing price spreads, and therefore potentially improving spatial efficiency and integration.[6]

5.2.1 Choice of market pairs

In order to choose market pairs, we have focused on roads that experienced significant rehabilitations in relatively close markets. Thus, the pairs selected here are mainly markets belonging to the same province or to a neighbouring province. The main idea behind this criterion is that it is very difficult to find cases of distant markets where a substantial part of the road has been rehabilitated. As a result, and since most of the existing analysis of market integration in Mozambique focuses on inter-province pairs of markets, this paper contributes to the literature by studying spatial efficiency for intra-provincial markets with additional accounting for periods before and after road rehabilitation. Table 4 summarises selected market pairs and the extent of road rehabilitation in these selected routes.[7] [8]

[6] These informal traders tend to depend on the availability of trucks and vans working on that route, often returning empty after delivering their load. We should expect that better road conditions increase the amount of vehicles transporting goods on the area.

[7] For the case of Xai-Xai-Chockwe, even though the road works carried out were considered as maintenance, improvements in road conditions were substantial. In addition, the rehabilitation of the route Tete-Chimoio was only partial, but substantial improvements were achieved.

5.2.2 Transaction costs

One of the main weaknesses of the PBM methodology is that it is highly dependent on the quality of transaction cost estimates. Furthermore, as described earlier, the impact of road rehabilitation on spatial market arbitrage is expected also to be transmitted via a reduction in transport costs.

Unfortunately transport cost data are scarce. The main source of data is provided by SIMA, but only available from 2001 and with very little frequency (See Table 5). Thus, we need to predict the transport and transaction costs values for most of our time span. This clearly constitutes a problem since for most of our market pairs road rehabilitation occurred in a period before SIMA start collecting transport cost data, and therefore, we can not test whether road rehabilitation impacted the trend of transport costs[9].

Due to this lack of data, we use sensitivity analysis and employ a methodology based on comparing the results when different sets of transaction costs estimates are used. Concretely, several sets of transaction costs series have been estimated:

i) MIC: For markets with one MIC (2001) observation available, we have constructed a series deflating the observation with diesel prices and adding a fixed mark up of 33%, as suggested by MIC (2001) as a constant commercialization mark-up. This method has been used in other papers such as Arndt and Penzhorn (2002) and Tostao and Brorsen (2002).

ii) SIMA (SIMA1 and SIMA2): For markets with several observations from the SIMA database, we use equation *(19)* and regress the existing observations on a

[8] Currently, significant works in the main country road, EN1, are being completed or about to be completed, especially in the route Maputo-Xai-Xai. It is, however, too soon to analyse the potential impact of this road rehabilitation on spatial arbitrage.

[9] As Table 5 shows, for the market pairs Nampula-Nacala, Pemba-Montepuez and Tete-Chimoio, road rehabilitation occurs after 2001 and therefore there is some SIMA data available. In all three cases, however, average transport costs are higher after road rehabilitation. This is quite likely to be the result of high increases in diesel prices.

constant, diesel prices and a dummy with value 1 for the months of commercialization.[10] The predicted values are used as transaction costs estimates. When the observations cover the period before and after road rehabilitation, the road rehabilitation dummy, a variable with value 1 after rehabilitation and 0 otherwise, is also added to the regression.[11]

$$TC_{ijt} = \beta_0 + \beta_1\ DIESEL_t + \beta_2\ COMER_t + \beta_3 ROAD_{ijt} + e_{ijt} \quad (19)$$

iii) Est1: This specification estimates constant transaction costs endogenously in the model, equations *(12)* to *(16)*.

iv) Est2: The forth specification incorporates equation *(19)* to the model and estimate transaction costs endogenously but controlling for the impact of diesel prices, commercialization period and road rehabilitation.

v) TC1: The fifth specification is based on the predicted values arising from estimating a panel with all the SIMA data available; this includes more than a 100 market pairs and 3872 observations. We estimate equation *(20),* where transport costs are a function of distance, diesel prices and a dummy for commercialization months, as a random effects model, and predict transport costs for all the market pairs of interest, inflated with a 30% mark-up.[12]

$$TC_{ijt} = \beta_t + \beta_1 DIST_{it} + \beta_2\ DIESEL_t + \beta_3\ COMER_t + e_{ijt} \quad (20)$$

vi) TC2: The last specification computes the yearly averages with the SIMA information available from 2001 to 2005, with a 30% mark-up. Then, it applies the average growth rate for this period in order to obtain values from 1995 to 2000. This specification it is only used for market pairs with data available, and applied for monthly specifications since it only has yearly variations.

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[10] We should expect that during the commercialization period the high increase in the demand of transport will put pressure on transport prices, increasing therefore transaction costs.

[11] Therefore, we have two specifications, SIMA1 without road effects when no data is available before rehabilitation, and SIMA2, when data is available and the road dummy is included.

[12] Due to the lack of transport costs observations before 2001, the dummy variable for road rehabilitation is not statistically significant and, therefore, excluded.

Table 5 summarizes data availability for each pair of markets regarding transport costs. A quick look at the plotted transaction costs in the Appendix shows that panel transaction costs estimates (TC) tend to overestimate transaction costs and are always higher than other estimates. On the other hand, endogenous estimates tend to underestimate transaction costs as compared with observed transaction costs in SIMA. For this reason, SIMA or TC2 transaction costs are preferred for most market pairs when data is available, since they provide market survey based information.

A significant problem arises from the fact that since SIMA transport costs data started to be collected in 2001, for only three[13] out of seven market pairs there are transport costs observations available for the period before the road was rehabilitated. This implies the need of comparing the results using different type of transport costs scenarios, and also, the need of focusing on the second channel of road rehabilitation increasing competition and reducing price differentials.

6. Results

Estimation of the models described in equations *(12)* to *(18)* were carried out using both weekly as well as monthly data. There are advantages/disadvantages to each approach. On the one hand, weekly data provides a greater number of observations and a greater degree of price variation. On the other hand, in Mozambique, it is difficult to assume that price differentials are arbitraged away on a weekly basis. In addition, monthly averages attenuate unusual very large price differentials. In all cases, price differentials have been deflated using the national monthly CPI index.

The impact of road rehabilitation was proxied by a dummy with value 1 for the months after road works were completed, and 0 otherwise (see equation 19). The assumption here is that there is a full impact of the road improvement on efficiency just after road works have finished.

[13] These market pairs are Nampula-Nacala, Pemba-Montepuez and Tete-Chimoio

Estimations are performed using GAMS and the Conopt solution algorithm. A Likelihood Ratio (LR) test is performed to test the null of non-significant change in probabilities after road rehabilitation (this is H_0: $\gamma_1=\gamma_3= 0$ in *(17) and (18)*).

Table A1 summarizes the main information regarding data availability associated with price differentials for every market pair. The time span for most market pairs goes from 1995 to 2005, with the exception of Maxixe-Homoine, where information is only available until 1999. In addition, for the cases of Xai-Xai-Chockwe and Pemba-Montepuez data from 2002 is much less frequent.

Price differences have tended to decrease. Table A1 shows that, for the period after road rehabilitation was completed, the average price differential decreased for all market pairs, except Manica-Chimoio and Nampula-Nacala.

Seven possible specifications have been estimated depending on data availability as defined in previous section 5.2.2: Est1, Est2, MIC, SIMA1, SIMA2, TC and TC2.

The results of the estimations by market pair are the following (see Appendix 2 for detailed information of the estimation results):

Beira-Chimoio

For this market pair, Table in Appendix 1 shows that the average price differential decreases during the period after the road rehabilitation, while price differential volatility increases. Price differentials tend to decrease with transaction costs; however, there is a mild shift of regime towards autarky. While in the first period the pair is inefficient around 60% of the time and there are significant rents to be arbitraged, during the period after road rehabilitation the pair is in autarky around 60-70% of time.

Using SIMA estimates for transaction costs as preferred estimates suggest similar results in terms of the final regime. The autarky regime prevails with very high probability. This is consistent with a positive impact of road rehabilitation reducing price spreads, while transaction costs may increase as a consequence of increasing fuel prices. Nevertheless, this specification indicates that there is no change of more likely regime on the period when road rehabilitation was completed; the autarky regime continues to be more frequent with similar probability. This is confirmed by the LR test.

Manica-Chimoio

In the case of these very close markets (65 kms) the picture portrait by the estimations is mixed. Weekly and monthly data specifications suggest different pictures. The only common result is that there seems to be a shift after road rehabilitation is in place to a situation of regime inefficiency. The LR test confirms that the change in probabilities is statistically significant. This is consistent with the fact illustrated in Appendix 1 that the average price differential has increased during the post-rehabilitation period. Several factors could explain this situation; for example, scarcity of maize for commercialization from bad production years or high barriers to entry in the market.

Weekly data specifications indicate a shift from an efficient regime, especially with constant transaction costs, towards a situation of inefficiency. The SIMA specification suggests shifting from efficiency with probability 22.9%, towards autarky 43.6% or inefficiency 56.3% during the post-road rehabilitation period.

On the other hand, when using monthly data, the initial main regime is autarky, between 70% (endogenous transaction costs) and 48.2% (SIMA estimates), and this tends to be equalized with the inefficient regime during the period of post-road rehabilitation.

Maxixe-Homoine

For this market pair, data was available only until July 1998 and there was no SIMA transaction costs information available. In this case, using weekly data, markets were originally in an efficient situation most of the time and inefficient around 43% of the time. During the post-road rehabilitation period, there is a clear reduction of the probability of an inefficient regime and an increase in the probability of being in autarky.

Using monthly data, there is an increase in efficiency from 60% to 80% of the time following rehabilitation for the case of constant transaction costs, and also an increase in the probability of the autarky regime. The LR test however indicates that the change in probabilities is not statistically significant.

This market pair is the only pair where the efficient regime seems to dominate. This is obviously highly dependent on the quality of endogenous transaction costs estimates, which as seen for other market pairs seem to underestimate transaction costs compared to SIMA. On the other hand, estimates using a panel of transaction costs, suggest an increase in the probability of the autarky regime; however, as we have seen for the other cases, this specification tends to overestimate transaction costs.

The SIMA database has recorded a significant amount of trade flows among both markets. In addition, Table in Appendix 1 shows a decrease in price spreads after road rehabilitation. This could support the idea of highly integrated markets.[14]

Nampula-Nacala

The pair Nampula-Nacala is in an inefficient regime in most of the specifications. The results clearly point to a change from being in autarky around 55%-60% of the time during the pre-rehabilitation period towards being in an inefficient regime in around 65%-75% during the post-road rehabilitation period. This is consistent with the large increase in the average price differential observed during the post-rehabilitation period (Table in Appendix 1).

The main explanation of this result may lie in the fact that the road was completed at the end of 2004. Thus, there are very few observations of the post-rehabilitation period that coincides with scarcity of maize for commercialization and the problems associated to it described in section 4.1. Furthermore, the LR test for the preferred TC2 specification indicates that the change in probabilities is not statistically significant.

[14] This market pair is the least distant of all the markets of analysis. In addition, it is the only unpaved road in the analysis.

Pemba- Montepuez

The results of Pemba-Montepuez are totally dependent on the series of transaction costs used. When using endogenous estimates there is a tendency towards shifting to an inefficient regime, mainly due to the fact that transaction costs are lower. The use of SIMA estimates indicates, on the contrary, a shift towards autarky in 80-90% of the time.

For this market pair, we have 91 SIMA observations available, before and after road rehabilitation, which imply that the series estimated should be more robust than the endogenous estimations, and therefore preferred. In this case, the increase in transaction costs due to diesel prices and other factors clearly outweighs the impact of road rehabilitation on transaction costs. This increase implies a shift towards the autarky regime, which is statistically significant using the LR test. This is confirmed by the preferred TC2 specification.

Tete-Chimoio

For this pair, the result also depends critically on the set of transaction costs estimates used. The common finding is a strong reduction on the probability of being in the inefficient regime at the end of the period. The fact that SIMA estimates are larger than the ones endogenously estimated, imply that for these preferred specifications the more likely regime is autarky.

It is important to point out in this case that only half of the road of this route has been rehabilitated. In addition, the LR test indicates that the change in probabilities in the two periods, before and after road-rehabilitation, is not statistically significant.

Xai-Xai-Chockwe

The last market pair seems to be most of the time in a spatially inefficient regime. However, the tendency in most of the specifications is to shift towards a reduction in inefficiency and increase in the probability of autarky, and slightly the probability of efficiency. Price differentials are also reduced and the change in regime probabilities after road rehabilitation is statistically significant using the LR test.

Common Results

It is important to stress that two main problems were found while performing the estimations. The first problem is the fact that the methodology is highly dependent on the quality of transaction costs estimates and, for some market pairs, there is only scattered information about transport costs. The second problem affecting the estimations is the fact that for some market pairs specifications, parameters estimates tended to be quite unstable.

Clearly, the picture that emerges from the estimations is diverse and market specific. Table 6 summarizes the main findings that arise from the estimations of the extended PBM methodology. The main conclusion that surfaces is that the selected intra-province markets do not tend to be spatially inefficient, with the exception of Manica-Chimoio and Nampula-Nacala, but tend to be in an autarky regime where price differentials are not arbitraged due to high transport costs.

As suggested above, transaction costs estimates are crucial in determining the spatial efficient regime. In this paper we have tried several transaction costs specifications. Endogenous estimates tend to estimate lower transaction costs as compared to existing observations. Furthermore, transaction costs based on one observation deflated on diesel or CPI prices, or based on panel estimates based on distance and diesel prices, tend to overestimate transaction costs and, therefore, seem to be biased towards identifying autarky and efficiency regimes with higher probability.

We should expect that road rehabilitation, by reducing transport costs and increasing the capacity to enter markets, would reduce the probability of being in an inefficient regime. Regarding the first channel, we only have transport costs observations before and after road rehabilitation for three market pairs. In these cases, total transaction costs continue increasing mainly due to fuel prices, which may offset any potential impact of road rehabilitation reducing transport costs. Regarding the second channel, we observe a reduction in price spreads for all market pairs, except the inefficient Manica-Chimoio and Nampula-Nacala.

LR tests performed on the significance of the coefficients linking regime probabilities with the periods before and after rehabilitation indicate that the impact is not statistically significant change for most market pairs. This could be interpreted as an indication that the impact of road rehabilitation is not large enough to change significantly regime probabilities, although two potential explanations should be considered. First, as suggested above, the fact that other factors, such as the increase in fuel prices, may dominate spatial efficiency before and after road rehabilitation. Second, the structure imposed on the road rehabilitation impact may be too restrictive. The use of a dummy with values zero and one implies the full transmission of the impact of road rehabilitation on the month after road works were completed. It is likely, that the first element may dominate, especially since we may expect a relatively rapid response of traders to improved road conditions.

Finally, we can conclude that the estimation results suggest that for most market pairs the probability of inefficient regimes is reduced during the post-road rehabilitation period; implying a potential positive impact of road rehabilitation on reducing spatial inefficiency.[15] The observed increase in the autarky regime may be consistent with an impact of road rehabilitation reducing transport costs, since the large increases observed in diesel prices could have offset the impact of road rehabilitation. In addition, we observed a reduction in price spreads, except for the two inefficient market pairs. Nevertheless, given the large scale investments in road rehabilitation, the result is neither as strong nor as robust as one would like.

6. Conclusions and Policy Implications

This paper has attempted to analyse the impact of road rehabilitation on spatial efficiency across provincial maize markets in Mozambique using an extended PBM

[15] Scarcity in the supply of maize for commercialization in recent years and the resulting high prices may be shifting some traders towards trading other products. Therefore, we may expect in the future a potential reduction in arbitrage and competition in maize markets.

methodology. At the methodological level we found that the quality of the results is extremely dependent on the quality of the transaction cost estimates. For this reason, we have estimated specifications using different transaction costs series in order to compare the results and improve their robustness. The methodology shows some instability in some of the parameter estimates and therefore this should be taken into consideration when interpreting the main findings of this paper.

Regarding the impact of road rehabilitation on spatial efficiency, we find ambiguous results. Selected intra-province markets in Mozambique do not tend to be spatially inefficient, with the exception of Manica-Chimoio and Nampula-Nacala. Although for most market pairs the probability of inefficient regimes is reduced during the post-road rehabilitation period, market pairs have tended to shift towards autarky regimes. The impact of road rehabilitation is, however, not statistically significant for most market pairs. Thus, the overall impact of road rehabilitation seems to be, however, small. This could be explained mainly by the fact that large diesel prices increases during the period may have offset any positive impact of road rehabilitation on reducing transport costs, and, therefore, increasing the probability of being in an autarky regime.

In our view, two main policy implications may arise as a result of the main findings of this paper:

- It is imperative to reduce transaction costs in order to integrate markets in Mozambique. Road rehabilitation is an instrument to do so, however, other transport options, such as rail and maritime transport, need to be effectively developed.
- In order to improve spatial efficiency and integration, road rehabilitation needs to be accompanied by policies that improve traders' market participation and arbitrage.

In addition, it is important to consider production issues when looking at enhancing spatial efficiency. Maize production dynamics needs to be considered when looking at market integration. Supply constraints that increase prices substantially, reduce the amount of maize to be commercialized and the flows between markets. This, in turn, reduces the degree of integration between markets. For this reason, in order to improve efficiency it is necessary to consider measures that can increase the amount of maize supplied for commercialization.

Predominance of the autarky regime in spatial integration in Mozambique implies that any policy reform at the macro level will have different impacts in different provinces, being fully transmitted to some while leaving others isolated. Thus, reducing transport costs, via road rehabilitation and maritime and rail transport, and improving provincial markets institutions in order to increase integration should be a priority for the country.

Tables and Figures

Table 1 ICM maize purchase

	1994	1995	1996	1997	1998	1999
Tones purchased by ICM	36,454	34,419	56,709	20,045	14,421	36,893

Source: ICM

Box 1 State Involvement in the Commercialization of Maize in Mozambique

During the colonial period, the commercialization of maize was done through the *Instituto dos Cereais de Moçambique* (ICM). The ICM was a parastatal monopsony with the mandate to buy maize from farmers. With independence, the ICM disappeared, and maize commercialization, jointly with other agriculture production, was commercialized by *Agricom*. This was a state owned company that controlled the commercialization of agricultural products during the period of centrally planned economy and beginning of market reforms, until the end of the war period.

With the end of the war and the beginning of the peace period, *Agricom* disappeared and in July 1994 the ICM was re-founded. The mandate of the new ICM was to become the buyer of the last resort, buying maize from farmers in remote areas where there was no private sector presence or areas where lack of infrastructure made commercialization very difficult. It inherited the infrastructure of *Agricom*, trucks, boats and storage facilities; but without having any resources for its renewal and very little funds for the purchase maize surpluses.

Soon after the ICM was created, three issues confronted the new institution. First, lack of funds and obsolete equipment made the ICM start to lose its capacity for intervention. Second, a few large private traders started operating in maize markets and commercialize maize in central and northern regions. Finally, after a period of significant increase in production, following the end of the war, maize production has remained very stagnant since 1998 (see Table 2), implying scarcity of maize surplus for commercialization.

The ICM carried out its last intervention in 1999 (see Table 1). The largest intervention was done in 1996 with approximately 5% of estimated production. Interventions were carried out according to local market prices and therefore prices were not fixed. Thus, ICM intervention is unlikely to have had much impact on spatial market arbitrage. After 1998, the ICM started to hire its infrastructure to private traders, becoming de facto inoperative in 2000[16].

Source: Author's own elaboration

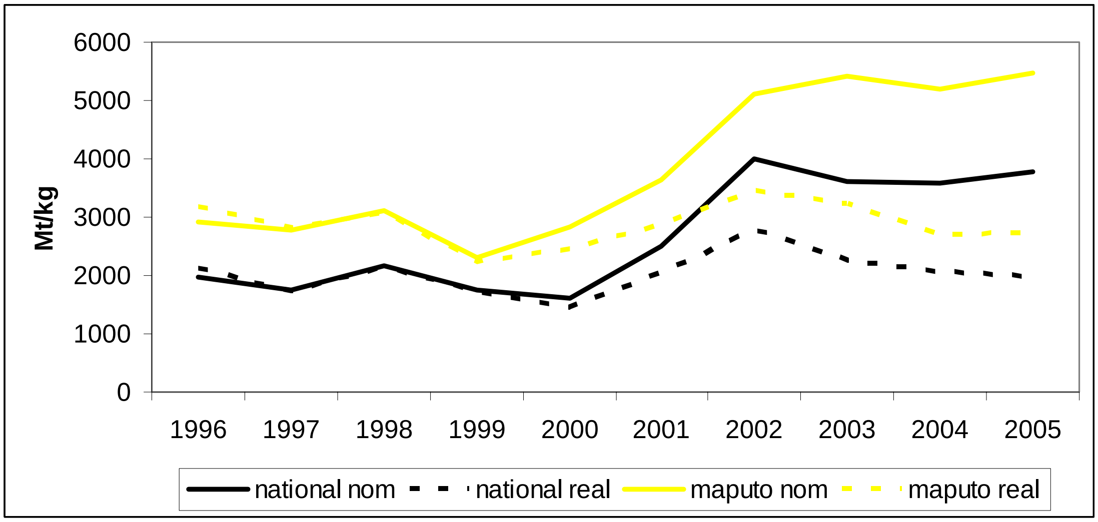
[16] The ICM is still an existing institution and the succeeding Government Commercialization Strategies propose a reform of its mandate and a re-orientation towards production oriented services. (MIC, 2005)

Table 2 Maize production estimates 1996-2004

Provinces	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04
Cabo Delgado	62,200	97,400	57,265	50,104	70,444	105,565	133,293	135,822
Niassa	175,800	173,500	144,568	121,641	134,327	178,633	199,556	204,848
Nampula	117,200	120,400	129,197	106,995	107,479	111,582	135,345	135,760
Zambezia	190,600	212,500	192,366	166,787	194,953	260,066	265,461	277,623
Tete	125,700	125,300	177,544	139,986	151,078	177,798	182,068	188,188
Manica	160,100	158,600	260,829	191,868	205,873	207,891	177,261	241,830
Sofala	64,700	71,800	105,333	74,568	79,668	70,234	80,150	86,410
Inhambane	47,900	59,800	104,466	83,022	75,921	40,014	28,206	42,607
Gaza	61,200	74,100	38,811	53,728	66,215	51,343	30,885	93,275
Maputo	36,800	30,200	35,699	30,335	57,305	32,532	15,672	28,384
Total	**1,042,200**	**1,123,600**	**1,246,078**	**1,019,033**	**1,143,263**	**1,235,657**	**1,247,897**	**1,434,746**

Source: Direcção Nacional de Agricultura, Sistema Nacional de Aviso Previo (SNAP)

Figure 1 Evolution of average [a] retail nominal and real white maize price (Mt/kg)



[a] National average of all SIMA observations available in all markets in one year. Real prices obtained by deflating nominal prices with the Maputo-Beira-Nampula CPI index, for national nominal price, and Maputo CPI index.

Table3 Investment in Road Rehabilitation per Province (current million US$)

Province	1998	1999	2000	2001	2002	2003	2004	*Total*
Maputo	0.835	0.856	0.888	0.931	1.442	1.686	2.453	9.092
Gaza	1.672	1.370	1.585	1.454	2.604	2.584	3.089	14.359
Inhambane	1.372	1.562	2.226	0.990	1.714	1.760	2.978	12.602
Sofala	1.351	1.150	1.636	0.729	1.523	2.275	1.862	10.527
Manica	0.947	1.174	1.255	0.707	1.137	1.539	1.654	8.413
Tete	0.910	1.081	0.849	0.384	1.509	1.579	1.641	7.952
Nampula	1.543	1.371	2.049	0.857	2.170	2.201	3.481	13.671
Zambezia	2.154	1.719	2.588	0.425	1.941	2.893	2.501	14.220
Cabo Delgado	1.534	1.363	1.884	0.720	2.015	2.079	1.501	11.096
Niassa	1.325	1.093	1.413	0.850	1.529	2.258	1.814	10.282
Total	***13.644***	***12.739***	***16.373***	***8.047***	***17.584***	***20.853***	***22.973***	***112.213***

Source: Ministerio Obras Publica e Habitação

Table 4 Markets selected and road rehabilitated

Markets	Province	Route Rehabilitated	Distance rehabilitated	Finalized
Beira-Chimoio	Sofala/Manica	Beira-Inchope (Nhamatanda)	134	Oct-99
		Inchope-Machipanda	154	Jun-97
Manica-Chimoio	Manica	Inchope-Machipanda	154	Jun-97
Maxixe-Homine	Inhambane	Maxixe-homoine	24	Dec-97
Nampula-Nacala	Nampula	Nampula-Nacala	199	Nov-04
Pemba-Montepuez	Cabo Delgado	Pemba-Montepuez	243	Jun-02
Tete-Chimoio	Tete/Manica	Partly finished		Dec-02
Chockwe-Xai.Xai	Gaza	Macia-Chockwe	62	Aug-98

Source: ANE

Table 5 Transport costs observations for selected pair of markets

	SIMA						MIC
	Obs	Mean	Std. Dev.	Min	Max		
Beira-Chimoio	27	437.037	139.705	228.571	857.143		No
Manica-Chimoio	9	230.159	122.567	142.857	500.000		No
Maxixe-Homine	0	No obs	for this	period			No
Nampula-Nacala	21	335.034	102.567	214.286	642.857		Yes
Pemba-Montepuez	91	471.743	116.584	142.857	857.143		Yes
Tete-Chimoio	34	684.874	177.697	428.571	1285.714		No
Xai-Xai-Chockwe	21	452.381	193.430	214.286	714.286		Yes

Source: SIMA and MIC (2001)

Table 6 Main results impact of road rehabilitation on spatial efficiency

				Change in probabilities		
	Road Rehabil.	**Reference transaction costs**	**Main Regime**	**Efficient λ_1**	**Autarky λ_2**	**Inefficient λ_3**
Beira-Chimoio	Before	SIMA	Autarky	0	0/+	0
	After		Autarky	Reduction price spreads		
	H_0: $\gamma_1=\gamma_3=0$		No change			
Manica-Chimoio	Before	SIMA	Autarky	-	-	+
	After		Inefficient	Increase price spreads		
	H_0: $\gamma_1=\gamma_3=0$		No change			
Maxixe-Homine	Before	Endog.	Efficient	+/0	+	-
	After		Efficient/Autarky	Reduction price spreads		
	H_0: $\gamma_1=\gamma_3=0$		No change			
Nampula-Nacala	Before	SIMA/TC2	Autarky	-	-	+
	After		Inefficient	Increase price spreads		
	H_0: $\gamma_1=\gamma_3=0$		No change			
Pemba-Montepuez	Before	SIMA/TC2	?	-	+	-
	After		Autarky	Reduction price spreads		
	H_0: $\gamma_1=\gamma_3=0$		Accept change			
Tete-Chimoio	Before	SIMA/TC2	Autarky	0/-	+	-
	After		Autarky	Reduction price spreads		
	H_0: $\gamma_1=\gamma_3=0$		No change			
Xai-Xai-Chockwe	Before	TC2	Inefficient	+/0	+	-
	After		Autarky	Reduction price spreads		
	H_0: $\gamma_1=\gamma_3=0$		Accept change			

+ positive increase, - reduction, 0 no impact and ? ambiguous impact
Source: Authors' own elaboration

Appendix 1

Markets		Price Differential (absolute value)					Period		Before		After	
		Obs	Mean	Std Dev	Min	Max	Average	Stdev	Average	Stdev	Average	Stdev
Beira-Chimoio	monthly	118	0.418	0.264	0.027	1.43	0.418	0.264	0.484	0.243	0.355	0.270
	weekly	418	0.43	0.337	0	2.826	0.431	0.337	0.469	0.317	0.383	0.356
Manica-Chimoio	monthly	121	0.329	0.226	0	1.148	0.330	0.226	0.274	0.167	0.347	0.240
	weekly	459	0.323	0.291	0	2.57	0.323	0.291	0.276	0.246	0.340	0.304
Maxixe-Homine	monthly	42	0.424	0.33	0	1.49	0.424	0.331	0.456	0.343	0.267	0.210
	weekly	162	0.421	0.374	0	1.687	0.421	0.375	0.438	0.378	0.320	0.347
Nampula-Nacala	monthly	121	0.367	0.312	0	1.369	0.367	0.312	0.353	0.301	0.603	0.406
	weekly	446	0.358	0.356	0	2.152	0.358	0.356	0.345	0.348	0.593	0.421
Pemba-Montepuez	monthly	88	0.339	0.22	0	1.22	0.340	0.220	0.350	0.221	0.308	0.219
	weekly	266	0.34	0.277	0	1.64	0.340	0.277	0.356	0.283	0.262	0.234
Tete-Chimoio	monthly	120	0.452	0.444	0.022	2.672	0.452	0.444	0.483	0.486	0.360	0.268
	weekly	425	0.465	0.505	0	3.65	0.466	0.505	0.492	0.551	0.387	0.319
Xai-Xai-Chockwe	monthly	89	0.496	0.367	0.048	1.916	0.496	0.367	0.604	0.467	0.426	0.267
	weekly	260	0.524	0.441	0	2.16	0.524	0.441	0.645	0.552	0.424	0.287

Source: Authors' own elaboration from SIMA

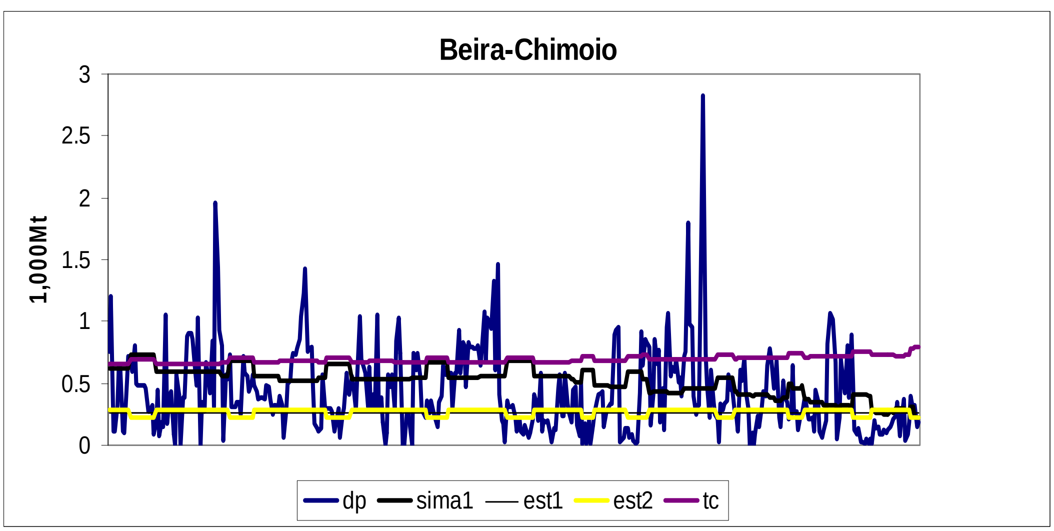
Appendix 2 Intra-Province markets. Road Rehabilitation.

Beira-Chimoio

Weekly data

	Est1	Est2	SIMA1	TC
MLE	-70.023	-66.48	-120.156	-123.901
sigmae	0.12	0.12	0.12	0.226
sigmau	0.1	0.1	0.281	0.341
sigmav	0.48	0.466	0.481	0.826
beta0	0.26	0.285		
beta1		0		
beta2		0		
beta3		-0.066		
gamma0	0.135	0.084	0.001	0.008
gamma1	-0.134	-0.083	0.025	-0.007
gamma2	0.231	0.265	0.769	0.941
gamma3	0.333	0.311	-0.06	0.035
Efficient λ_1 t	0.135	0.084	0.001	0.008
T+1	0.001	0.001	0.026	0.001
Autarky λ_2 t	0.231	0.265	0.769	0.941
T+1	0.564	0.576	0.71	0.976
Non-Efficient λ_3 t	0.634	0.651	0.23	0.051
T+1	0.435	0.423	0.265	0.023
MLE rest.	-77.141	-69.488	-114.958	-124.567
LR Test	14.236	6.016	-10.396	1.332

[a] restriction gamma1=gamma3=0
[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

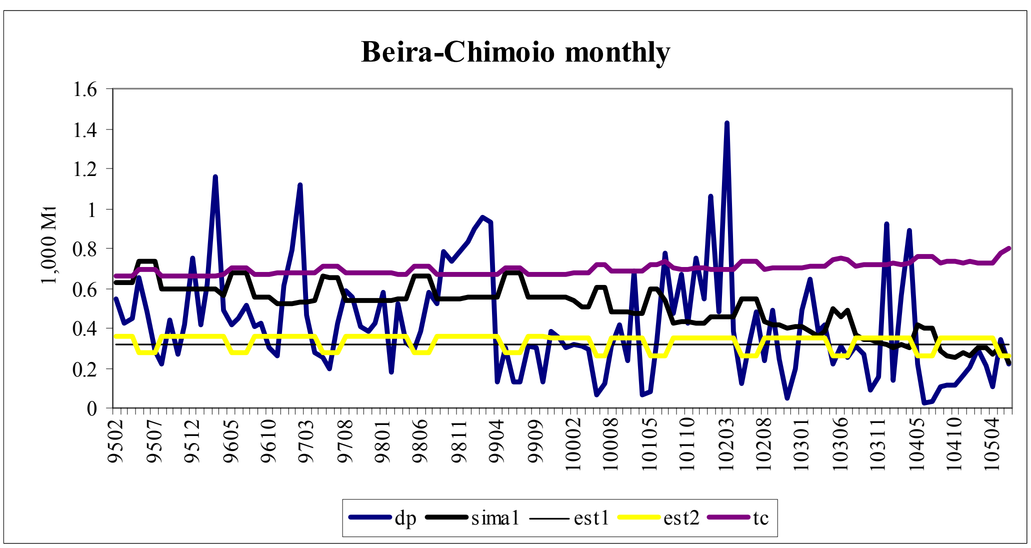


Monthly data

	Est1	Est2	SIMA1	TC
MLE	9.504	12.201	-4.379	-18.755
sigmae	0.12	0.121	0.12	0.12
sigmau	0.1	0.1	0.221	0.377
sigmav	0.38	0.37	0.376	0.333
beta0	0.32	0.359		
beta1		0		
beta2		-0.012		
beta3		-0.084		
gamma0	0.436	0.475	0.001	0.001
gamma1	-0.435	-0.474	1.11E-15	1.11E-15
gamma2	0.001	0.001	0.796	0.863
gamma3	0.711	0.72	2.46E-04	0.083
Efficient λ_1 t	0.436	0.475	0.001	0.001
T+1	0.001	0.001	0.001	0.001
Autarky λ_2 t	0.001	0.001	0.796	0.863
T+1	0.712	0.721	0.796	0.946
Non-Efficient λ_3 t	0.563	0.524	0.203	0.136
T+1	0.287	0.278	0.203	0.053
MLE rest.	2.486	11.832	-4.379	-18.715
LR Test	14.036	0.738	0	-0.08

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

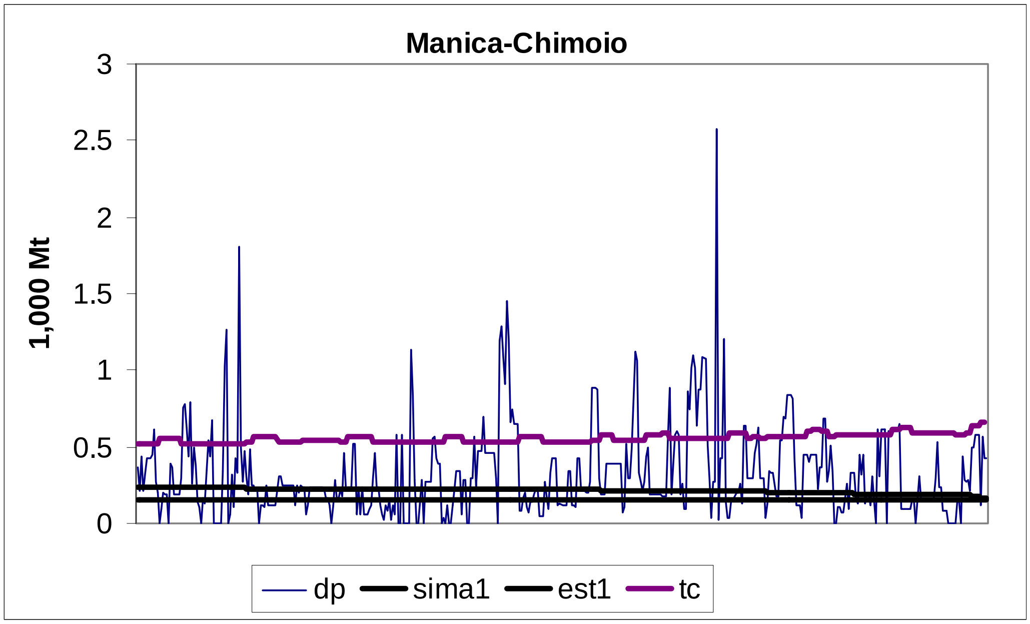


Manica-Chimoio

Weekly data

	Est1	Est2	SIMA1	TC
MLE	24.224	48.248	25.984	-51.957
sigmae	0.108	0.02	0.02	0.12
sigmau	0.1	0.137	0.129	0.33
sigmav	0.465	0.461	0.419	0.566
beta0	0.159	0.238		
beta1		4.31E-04		
beta2		-0.254		
beta3		-0.013		
gamma0	0.692	0.24	0.229	0.001
gamma1	-0.209	-0.239	-0.228	0
gamma2	0.001	0.437	0.43	0.956
gamma3	0	-0.436	0.005	-0.059
Efficient λ_1 t	0.692	0.24	0.229	0.001
T+1	0.482	0.001	0.001	0.001
Autarky λ_2 t	0.001	0.437	0.43	0.956
T+1	0.001	0.001	0.436	0.857
Non-Efficient λ_3 t	0.307	0.323	0.341	0.043
T+1	0.517	0.998	0.563	0.102
MLE rest.	20.324	21.969	15.216	-53.612
LR Test	7.8	52.558	21.536	3.31

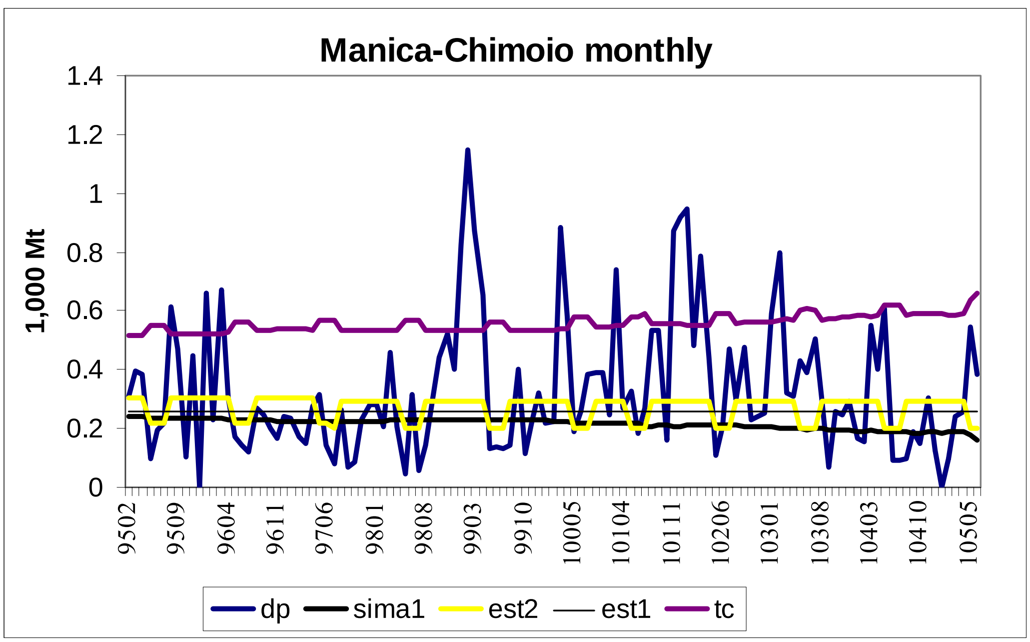
[a] restriction gamma1=gamma3=0
[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



Monthly data

	Est1	Est2	SIMA1	TC
MLE	30.889	36.242	28.115	1.096
sigmae	0.055	0.02	0.02	0.02
sigmau	0.1	0.115	0.1	0.329
sigmav	0.331	0.322	0.314	0.286
beta0	0.257	0.304		
beta1		1.00E-05		
beta2		-0.013		
beta3		-0.088		
gamma0	0.078	0.001	0.08	0.001
gamma1	-0.047	0.025	-0.077	0
gamma2	0.628	0.705	0.482	0.896
gamma3	-0.141	-0.2	-0.149	-0.035
Efficient λ_1 t	0.078	0.001	0.08	0.001
T+1	0.031	0.026	0.003	0.001
Autarky λ_2 t	0.628	0.705	0.482	0.896
T+1	0.488	0.504	0.334	0.861
Non-Efficient λ_3 t	0.294	0.294	0.438	0.103
T+1	0.481	0.47	0.664	0.138
MLE rest.	29.752	35.135	28.616	1.142
LR Test	2.274	2.214	-1.002	-0.092

[a] restriction gamma1=gamma3=0
[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



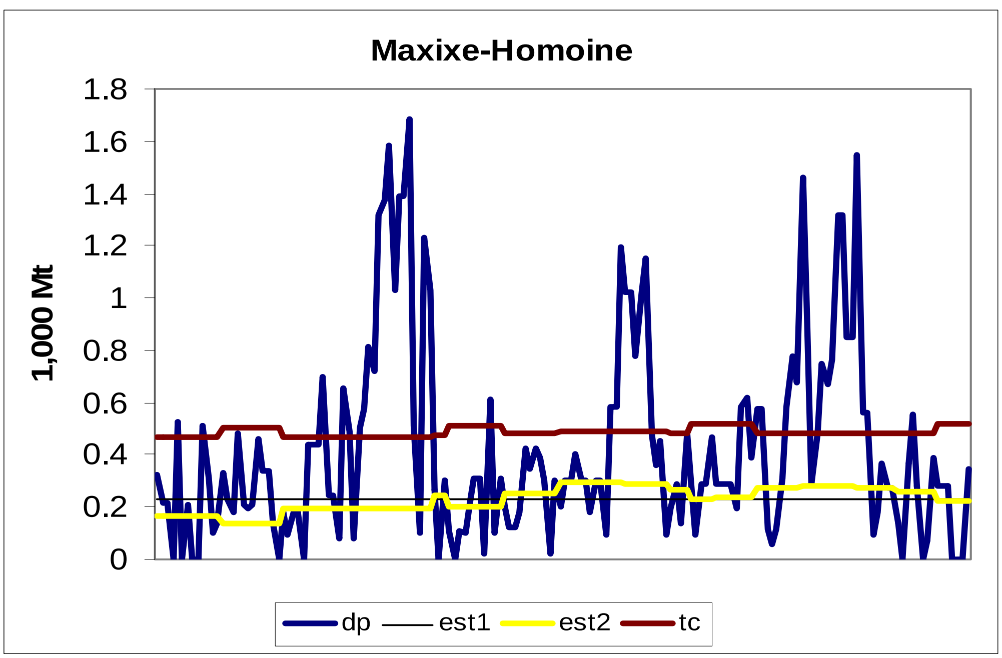
Maxixe-Homoine

Weekly data

	Est1	Est2	TC
MLE	-29.161	-25.359	-47.5429
sigmae	0.147	0.141	0.02
sigmau	0.1	0.1	0.297
sigmav	0.633	0.62	0.533
beta0	0.227	0.1	
beta1		0.034	
beta2		0	
beta3		-0.037	
gamma0	0.572	0.562	0.001
gamma1	0.101	-0.105	0
gamma2	0.001	0.001	0.684
gamma3	0.182	0.426	0.142
Efficient λ_1 t	0.572	0.562	0.001
T+1	0.673	0.456	0.001
Autarky λ_2 t	0.001	0.001	0.684
T+1	0.183	0.427	0.825
Non-Efficient λ_3 t	0.427	0.437	0.315
T+1	0.144	0.117	0.174
MLE rest.	-31.265	-26.892	-41.425
LR Test	4.208	3.066	-12.2358

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

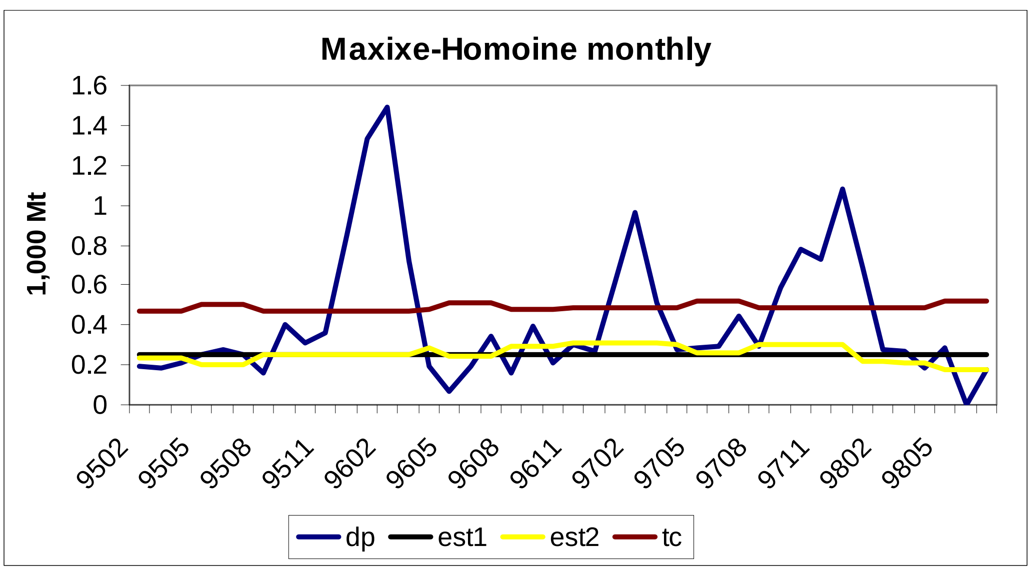


Monthly data

	Est1	Est2	TC
MLE	4.735	5.862	-5.591
sigmae	0.1	0.1	0.02
sigmau	0.1	0.1	0.257
sigmav	0.58	0.572	0.49
beta0	0.252	0.194	
beta1		0.021	
beta2		-0.081	
beta3		-0.04	
gamma0	0.579	0.601	0.001
gamma1	-0.305	0.211	0
gamma2	0.001	0.001	0.697
gamma3	0.553	0	0.159
Efficient λ_1 t	0.579	0.601	0.001
T+1	0.274	0.812	0.001
Autarky λ_2 t	0.001	0.001	0.302
T+1	0.554	0.001	0.856
Non-Efficient λ_3 t	0.42	0.398	0.302
T+1	0.171	0.187	0.143
MLE rest.	3.307	5.466	-5.418
LR Test	2.856	0.792	-0.346

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



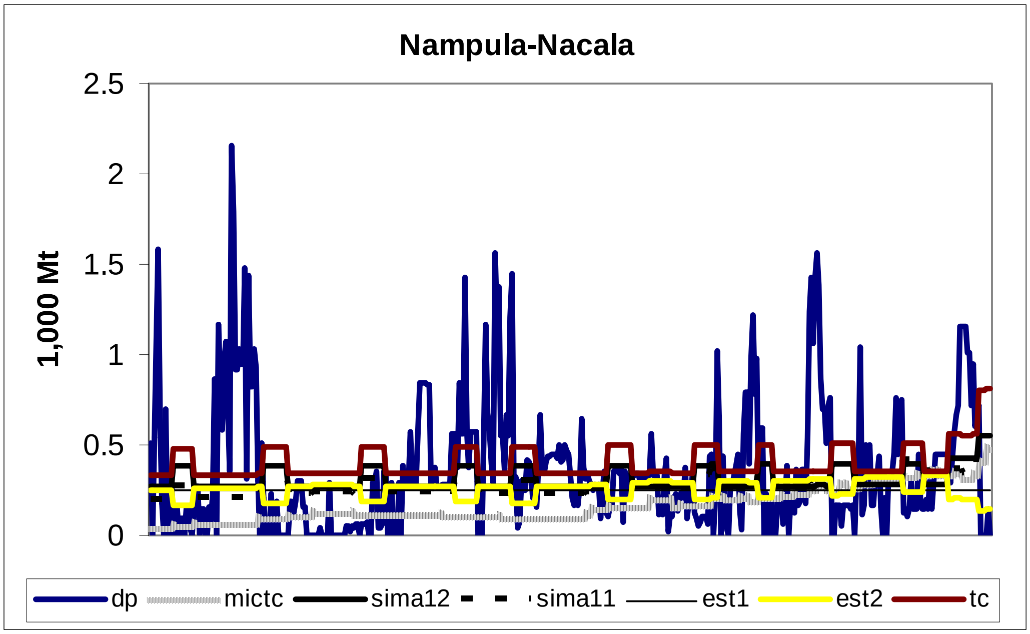
Nampula-Nacala

Weekly data

	Est1	Est2	MIC	SIMA1	SIMA2	TC
MLE	-63.801	-51.548	-107.419	-108.057	-119.492	-191.929
sigmae	0.137	0.129	0.07	0.07	0.07	0.07
sigmau	0.1	0.1	0.121	0.199	0.226	0.503
sigmav	0.587	0.585	0.514	0.551	0.535	0.495
beta0	0.253	0.244				
beta1		6.00E-03				
beta2		-0.132				
beta3		-0.088				
gamma0	0.073	0.001	0.001	0.105	0.085	0.001
gamma1	-0.072	0	0	-0.104	-0.084	0.035
gamma2	0.622	0.697	0.396	0.532	0.568	0.887
gamma3	-0.355	-0.485	-0.09	-0.222	-0.22	-0.259
Efficient λ_1 t	0.073	0.001	0.001	0.105	0.085	0.001
T+1	0.001	0.001	0.001	0.001	0.001	0.036
Autarky λ_2 t	0.622	0.697	0.396	0.532	0.568	0.887
T+1	0.268	0.213	0.307	0.31	0.348	0.629
Non-Efficient λ_3 t	0.305	0.302	0.603	0.363	0.347	0.112
T+1	0.731	0.786	0.692	0.689	0.651	0.335
MLE rest.	-70.18	-58.167	-94.547	-97.689	-110.146	-185.522
LR Test	12.758	13.238	-25.744	-20.736	-18.692	-12.814

[a] restriction gamma1=gamma3=0

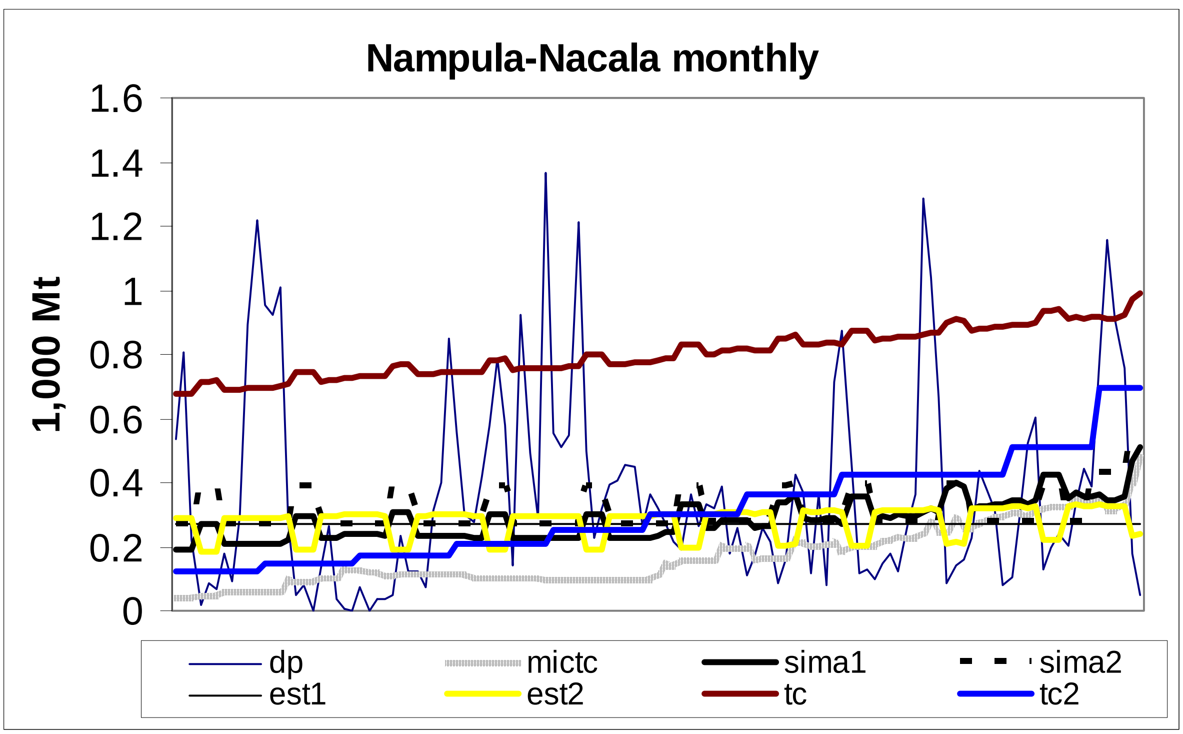
[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



Monthly data

	Est1	Est2	MIC	SIMA1	SIMA2	TC	TC2
MLE	-3.415	1.29	-17.002	-17.648	-20.778	-54.026	-23.02
sigmae	0.11	0.1	0.07	0.07	0.07	0.07	0.07
sigmau	0.1	0.1	0.116	0.167	0.196	0.559	0.212
sigmav	0.485	0.474	0.478	0.473	0.456	0.321	0.488
beta0	0.272	0.283					
beta1		3.00E-03					
beta2		0					
beta3		-0.105					
gamma0	0.001	0.001	0.146	0.057	0.068	0.001	0.145
gamma1	0	0	-0.145	-0.056	-0.067	0.032	-0.081
gamma2	0.648	0.65	0.259	0.538	0.548	0.894	0.489
gamma3	-0.371	-0.365	0.078	-0.196	-0.152	-0.102	0.002
Efficient λ_1 t	0.001	0.001	0.146	0.057	0.068	0.001	0.145
T+1	0.001	0.001	0.001	0.001	0.001	0.033	0.063
Autarky λ_2 t	0.648	0.65	0.259	0.538	0.548	0.894	0.489
T+1	0.277	0.285	0.337	0.342	0.396	0.792	0.491
Non-Efficient λ_3 t	0.351	0.349	0.596	0.406	0.384	0.105	0.366
T+1	0.722	0.714	0.662	0.657	0.603	0.175	0.446
MLE rest.	-4.762	0.064	-15.666	-16.043	-19.023	-48.064	-22.129
LR Test	2.694	2.452	-2.672	-3.21	-3.51	-11.924	-1.782

[a] restriction gamma1=gamma3=0
[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



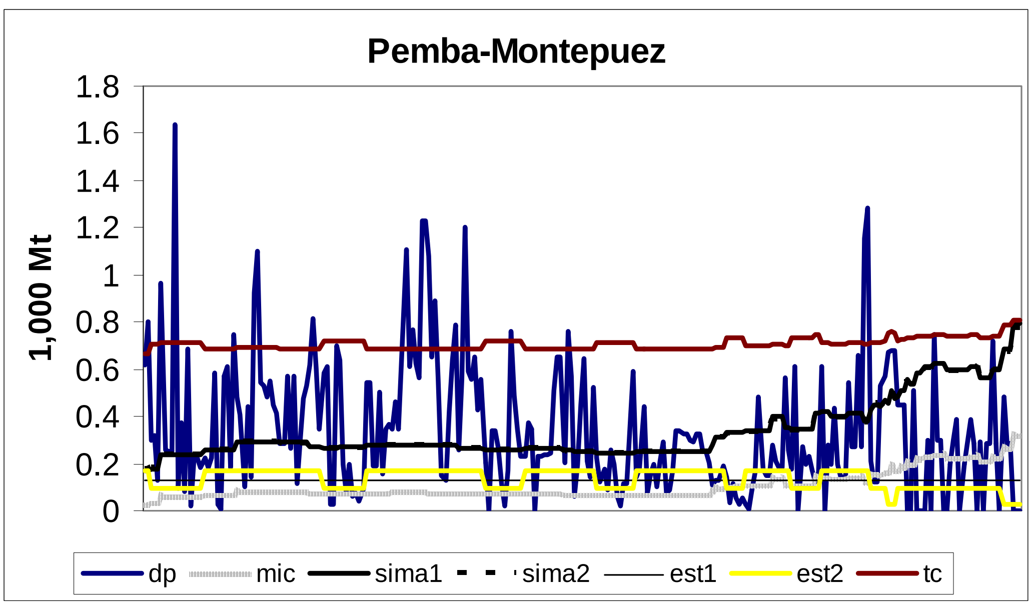
Pemba-Montepuez

Weekly Data

	Est1	Est2	MIC	SIMA1	SIMA2	TC
MLE	11.888	19.538	-2.313	-53.59	-51.753	-55.568
sigmae	0.079	0.076	0.09	0.09	0.09	0.09
sigmau	0.1	0.1	0.178	0.276	0.274	0.456
sigmav	0.414	0.411	0.413	0.394	0.395	0.44
beta0	0.13	0.167				
beta1		1.00E-05				
beta2		-0.069				
beta3		-0.07				
gamma0	0.329	0.362	0.168	0.16	0.17	0.001
gamma1	-0.328	-0.361	-0.076	-0.159	-0.169	-1.39E-17
gamma2	0.001	0.001	0.001	0.406	0.395	0.934
gamma3	0.375	0.315	0.475	0.51	0.523	0.064
Efficient λ_1 t	0.329	0.362	0.168	0.16	0.17	0.001
T+1	0.001	0.001	0.093	0.001	0.001	0.001
Autarky λ_2 t	0.001	0.001	0.001	0.406	0.395	0.934
T+1	0.376	0.316	0.476	0.917	0.918	0.998
Non-Efficient λ_3 t	0.67	0.637	0.831	0.434	0.434	0.065
T+1	0.623	0.683	0.431	0.082	0.081	0.001
MLE rest.	4.154	18.688	-23.771	-65.755	-64.584	-57.833
LR Test	15.468	1.7	42.916	24.33	25.662	4.53

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

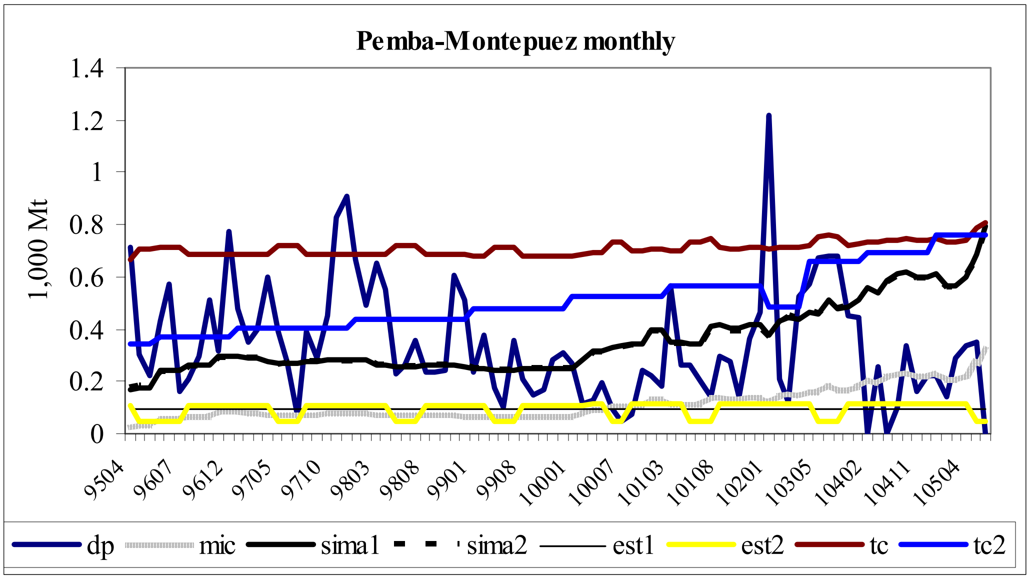


Monthly Data

	Est1	Est2	MIC	SIMA1	SIMA2	TC	TC2
MLE	20.258	22.575	13.45	-1.17	0.02	-6.321	-6.391
sigmae	0.041	0.031	0.1	0.1	0.1	0.1	0.1
sigmau	0.1	0.1	0.143	0.314	0.315	0.424	0.309
sigmav	0.335	0.334	0.331	0.317	0.319	0.348	0.303
beta0	0.095	0.111					
beta1		1.00E-05					
beta2		0					
beta3		-0.063					
gamma0	0.022	0.005	0.001	0.467	0.489	0.001	0.001
gamma1	-0.021	0.008	0.184	-0.466	-0.488	0	0
gamma2	0.001	0.001	0.001	0.171	0.149	0.963	0.775
gamma3	0.159	0.168	0.295	0.658	0.685	0.035	0.223
Efficient λ_1 t	0.022	0.005	0.001	0.467	0.489	0.001	0.001
T+1	0.001	0.013	0.185	0.001	0.001	0.001	0.001
Autarky λ_2 t	0.001	0.001	0.001	0.171	0.149	0.963	0.775
T+1	0.16	0.169	0.296	0.83	0.834	0.998	0.998
Non-Efficient λ_3 t	0.977	0.994	0.998	0.362	0.362	0.036	0.224
T+1	0.839	0.819	0.519	0.169	0.165	0.001	0.001
MLE rest.	19.233	22.289	6.693	-9.629	-9.108	-6.652	-9.232
LR Test	2.05	0.572	13.514	16.918	18.256	0.662	5.682

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



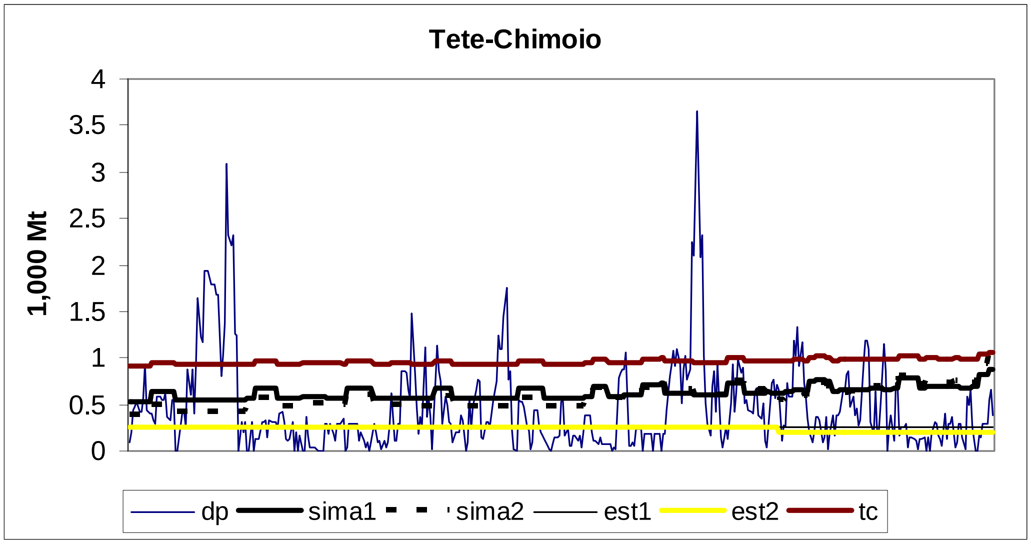
Tete-Chimoio

Weekly Data

	Est1	Est2	SIMA1	SIMA2
MLE	-153.47	-152.503	-239.013	-247.218
sigmae	0.117	0.124	0.095	0.095
sigmau	0.1	0.1	0.411	0.388
sigmav	0.815	0.818	0.873	0.87
beta0	0.251	0.258		
beta1		1.00E-05		
beta2		-0.059		
beta3		-0.002		
gamma0	0.001	0.001	0.001	0.001
gamma1	0.259	0.606	2.64E-16	2.64E-16
gamma2	0.553	0.567	0.767	0.735
gamma3	-0.172	0.566	0.107	0.128
Efficient λ_1 t	0.001	0.001	0.001	0.001
T+1	0.26	0.607	0.001	0.001
Autarky λ_2 t	0.553	0.567	0.767	0.735
T+1	0.381	0.001	0.874	0.863
Non-Efficient λ_3 t	0.446	0.432	0.232	0.264
T+1	0.359	0.392	0.125	0.136
MLE rest.	-154.793	-154.793	-228.596	-235.102
LR Test	2.646	4.58	-20.834	-24.232

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

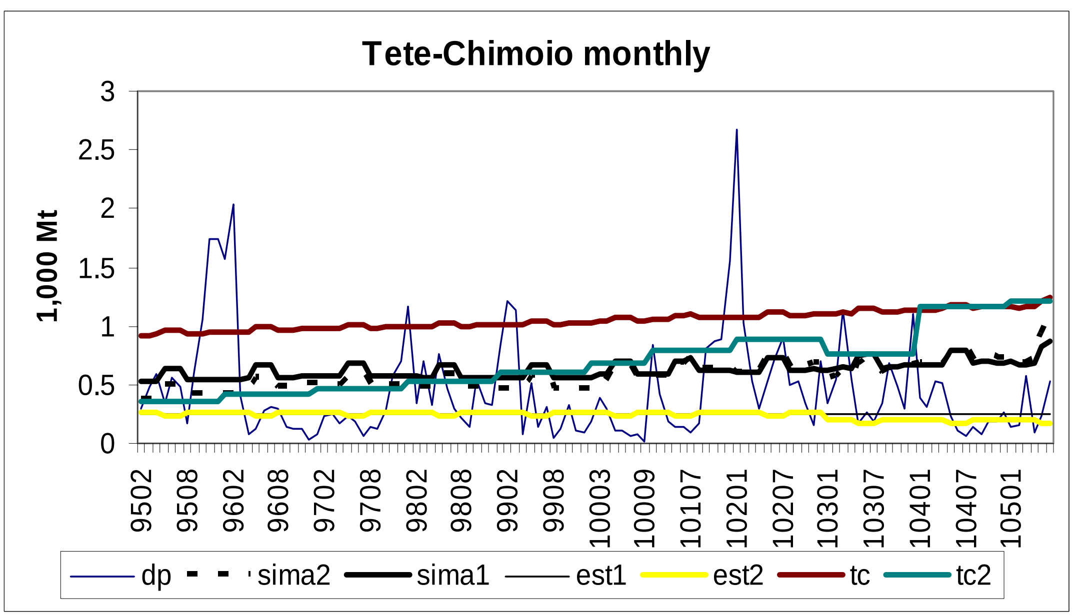


Monthly Data

	Est1	Est2	SIMA1	SIMA2	TC	TC2
MLE	-26.144	-25.001	-52.792	-55.265	-84.813	-80.98
sigmae	0.076	0.084	0.095	0.095	0.095	0.095
sigmau	0.1	0.1	0.389	0.37	0.742	0.533
sigmav	0.688	0.688	0.79	0.777	0.816	0.778
beta0	0.248	0.261				
beta1		1.00E-05				
beta2		-0.06				
beta3		-0.027				
gamma0	0.001	0.001	0.001	0.001	0.001	0.045
gamma1	0.169	0.552	2.25E-15	2.25E-15	0	-0.044
gamma2	0.495	0.509	0.782	0.74	0.905	0.73
gamma3	-0.075	-0.508	0.147	0.188	0.093	0.202
Efficient λ_1 t	0.001	0.001	0.001	0.001	0.001	0.045
T+1	0.17	0.553	0.001	0.001	0.001	0.001
Autarky λ_2 t	0.495	0.509	0.782	0.74	0.905	0.73
T+1	0.42	0.001	0.93	0.928	0.998	0.932
Non-Efficient λ_3 t	0.504	0.49	0.217	0.259	0.094	0.225
T+1	0.41	0.446	0.069	0.071	0.001	0.007
MLE rest.	-26.552	-26.185	-52.968	-55.072	-85.063	-79.924
LR Test	0.816	2.368	0.352	-0.386	0.5	-2.112

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



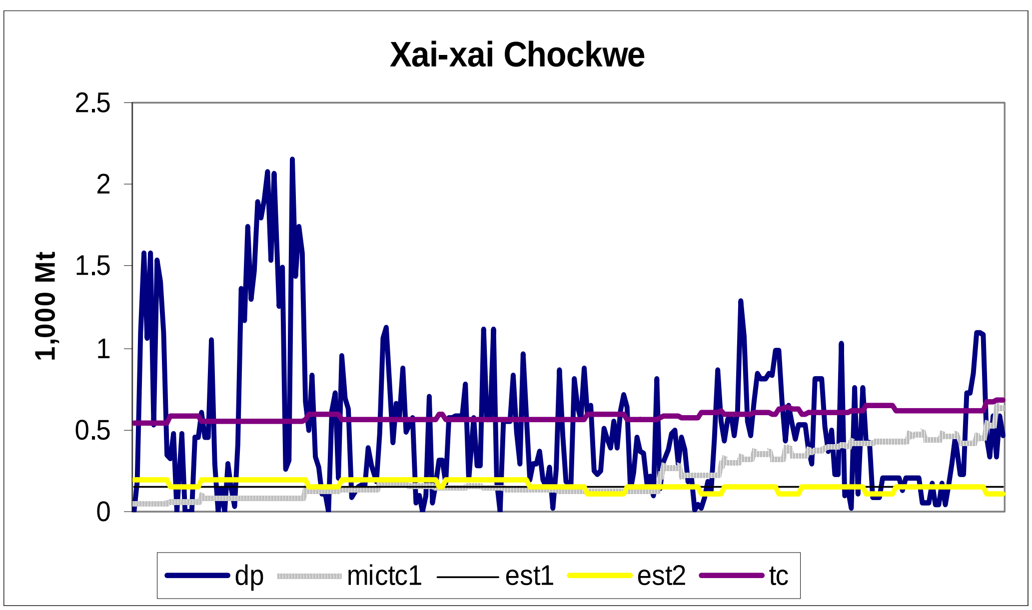
Xai-Xai-Chockwe

Weekly data

	Est1	Est2	MIC	TC
MLE	-98.978	-97.743	-134.941	-115.463
sigmae	0.078	0.078	0.14	0.14
sigmau	0.1	0.1	0.181	0.305
sigmav	0.655	0.653	0.689	0.688
beta0	0.149	0.19		
beta1		0.00001		
beta2		-0.043		
beta3		-0.034		
gamma0	0.001	0.001	0.171	0.001
gamma1	0.308	0.284	-8.40E-02	0
gamma2	0.193	0.234	0.001	0.629
gamma3	-0.192	-0.233	0.429	0.233
Efficient λ_1 t	0.001	0.001	0.171	0.001
T+1	0.309	0.285	0.087	0.001
Autarky λ_2 t	0.193	0.234	0.001	0.629
T+1	0.001	0.001	0.43	0.862
Non-Efficient λ_3 t	0.806	0.765	0.828	0.37
T+1	0.69	0.714	0.483	0.137
MLE rest.	-102.172	-100.603	-149.136	-103.741
LR Test	6.388	5.72	28.39	-23.444

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99

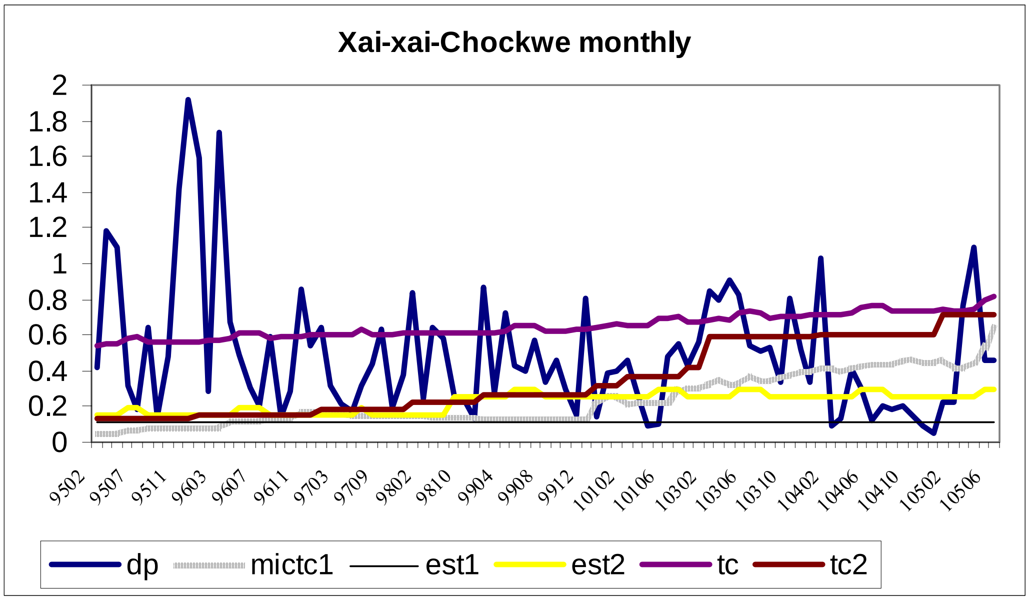


Monthly data

	Est1	Est2	MIC	TC	TC2
MLE	-13.434	-9.643	-32.09	-27.693	-31.548
sigmae	0.032	0.01	0.14	0.14	0.14
sigmau	0.1	0.1	3158	0.322	0.299
sigmav	0.552	0.549	551	0.685	0.594
beta0	0.112	0.15			
beta1		0.00001			
beta2		0.107			
beta3		0.04			
gamma0	0.001	0.097	0.001	0.033	0.112
gamma1	0.134	-0.096	0.046	-0.032	0.17
gamma2	0.001	0.001	0.001	0.702	0.001
gamma3	0	0	0.423	0.242	0.503
Efficient λ_1 t	0.001	0.097	0.001	0.033	0.112
T+1	0.135	0.001	0.047	0.001	0.282
Autarky λ_2 t	0.001	0.001	0.001	0.702	0.001
T+1	0.001	0.001	0.424	0.943	0.504
Non-Efficient λ_3 t	0.998	0.902	0.998	0.266	0.887
T+1	0.864	0.998	0.53	0.056	0.215
MLE rest.	-15.69	-10.461	-40.693	-29.017	-42.793
LR Test	4.512	1.636	17.206	2.648	22.49

[a] restriction gamma1=gamma3=0

[b] Likelihood-Ratio test - critical value at 95% confidence level , 5.99



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