KATHOLIEKE UNIVERSITEIT
LEUVEN

Faculty of Economics and
Applied Economics

Department of Economics

Dynamic Price Adjustment in Spatially Separated Food Markets with Transaction Costs Community Targeting for Poverty Reduction in Burkina Faso.

by

Stefan DERCON
Bjorn VAN CAMPENHOUT

Development Economics

Center for Economic Studies
Discussions Paper Series (DPS) 99.09
http://www.econ.kuleuven.be/ces/discussionpapers/default.htm

March 1999

DISCUSSION
PAPER

DYNAMIC PRICE ADJUSTMENT IN SPATIALLY SEPARATED FOOD MARKETS WITH TRANSACTION COSTS

Stefan Dercon*[+] and Bjorn Van Campenhout*
*Katholieke Universiteit Leuven

and

[+]Centre for the Study of African Economies
Institute of Economics and Statistics
St Cross Building
Manor Road
Oxford OX1 3UL
United Kingdom
stefan.dercon@econ.kuleuven.ac.be

Revised August 1998

Abstract

This paper presents an alternative technique to analyze market integration using price data, linking the cointegration version of Ravallion's dynamic model with the recent switching regression approaches as in Baulch's Parity Bounds Model. The Band-Threshold Autogression (Band-TAR) model allows for dynamic analysis of the adjustment process as well as for trade discontinuities and transaction costs, thereby avoiding some of the unrealistic assumptions of both approaches. We apply the model to the same rice price data on the Philippines as Baulch and find that, contrary to Baulch, the efficient arbitrage conditions are often not satisfied and unexploited profits are common, albeit relatively small. At least on one important trade route, we find evidence of substantial inefficiences.

Efficient arbitrage lies at the heart of any well-functioning market economy. In the wake of extensive economic reform and market liberalisation in many developing countries, information about how well markets function is necessary for the evaluation of policy. Time series on prices in spatially separated markets are increasingly available and have been used extensively to analyse market integration. Following Ravallion, time series econometric techniques have been used to assess the extent of interconnectedness of markets. Since prices are typically non-stationary, the tests implied in the Ravallion model have been reworked in terms of cointegration and error-correction models (Palaskas and Harriss-White, Alexander and Wyeth, Goodwin and Schroeder). In this approach, market integration becomes equivalent to co-movement of prices and the extent of market integration is measured via the speed of the return to a long run statistical relationship. The simplicity of the analysis has resulted in a large number of applications.

These approaches have been criticised on a number of grounds (Barrett). Theoretically, the presence of a stable long run margin between markets could be consistent with monopolistic pricing and other causes of inefficiencies (Faminow and Benson). Furthermore, and rarely remarked upon in food market analysis, contrary to in financial market analysis, fully efficient markets should not be cointegrated. Otherwise there would exist at least one Granger-causal relationship between the markets, implying that profit could be made from using information on past prices to predict present prices (Granger and Escribano). In other words, cointegration is consistent with an interconnected market, but not with a fully efficient (or perfectly integrated) market, since profitable trade remains unexploited at times[1]. Even more problematic, the model assumes that trade flows are permanent without any reversal of flows, which may not be consistent with seasonal trade flow patterns and the presence of transaction costs limiting profitable arbitrage (Sexton, Kling and Carman, Baulch). Sexton, Kling and Carman have some information on the trade flows and combine this with price data to estimate a switching regression model that endogenises transaction costs. Baulch extends this model, *inter alia* by explicitly introducing information on transactions costs in the model, by allowing trade flow reversals to take place and by linking it more directly to the spatial equilibrium model (Takayama and Judge). In this model, which he calls the Parity Bounds Model, the extent of market integration is expressed in terms of a continuous measure of the frequency of each the possible regimes (no profitable trade, efficient trade and non-exploited profitable trade opportunity) over the time period considered. Baulch presents some Monte Carlo evidence suggesting that the approach to be

[1] Note that this is not necessarily true if prices are assumed to be measured with error. In this case, cointegration could be fully consistent with a perfectly integrated market.

statistically more reliable, compared to the standard cointegration and error-correction models. Variations of the model have been used to analyse markets in the U.S., the Philippines and in China (Sexton, Kling and Carman; Baulch; Rozelle, Park, Huang and Jin; Fafchamps and Gavian).

The ability to consider transactions costs explicitly and to model discontinuous and reversing trade flows (or use information on it) is clearly an improvement over the simple cointegration and error-correction models (Barrett). Nevertheless, in this paper, we will argue that despite the shortcomings of cointegration analysis, the child should not be thrown out with the bath water. Switching regression models (as used in market analysis) are not dynamic and as a consequence do not contain information about the speed of adjustment of prices when profitable trade opportunities exist. As will be argued below, they employ very strong and rather unrealistic distributional assumptions, influencing identification too much for comfort. The challenge, therefore, is to find a dynamic model that allows for transactions costs and for discontinuous or reversing trade flows, that allows for informationally efficient markets and that allows inference about the adjustment process during arbitrage. Threshold cointegration techniques, in particular, the Band-TAR model, provide such an opportunity (Balke and Fomby, Prakash and Taylor). In the analysis, we will develop this model in the context of market integration analysis and apply it to the same data from the Philippines as used by Baulch. The estimation results reveal that in the long-run, all markets are connected. In the short run, contrary to Baulch's results, markets are not systematically satisfying the efficient arbitrage conditions. We will discuss the reasons for these diverging results.

STATISTICAL MODELS TO TEST MARKET INTEGRATION

Let C_t^{ij} be the transactions cost of moving grain between markets i and j in period t. Let P_t^i be the price of grain in market i. Efficient spatial arbitrage (Takayama and Judge) requires then that there are unexploited profits from trade between market i and j unless:

$$\left| P_t^i - P_t^j \right| \leq C_t^{ij} \tag{1}$$

Non-zero trade flows under efficient arbitrage would imply equality of both sides in (1). Efficient arbitrage could imply flows from i to j and from j to i, depending on market conditions in i and j. When (1) is valid with equality, prices are said to be at the parity bound. If margins are larger than the parity bounds, profitable trade could take place. Strict inequality of (1) would require zero trade flows. As in Ravallion, if (1) is valid, then the two spatially separated markets will be referred to as integrated. A weaker form of market integration could be defined as requiring (1) only to be valid in the long run: deviations could occur in the short run, but arbitrage would in due course return the market to satisfy (1).

There have been different approaches to develop this into a statistical model of market integration. Cointegration models only use price data and test whether in the long run there is a particular stable relationship between prices in i and j. Note that for these models to be consistent with the efficient arbitrage model, they require continuous trade and no flow reversal. The model tested is:

$$P_t^i = a + b.P_t^j + h_t \qquad (2)$$

Stationarity of η_t implies the existence of a long-run relationship between prices: they move together. Implicit in the model, trade is taking place continuously and in one direction only. Errors are made, however, and they are corrected over some period of time. The Engle-Granger results imply the existence of an error-correction representation that models this correction process over time. Testing restrictions on this error-correction model allows inference about the speed of adjustment to this long-run relationship (Palaskas and Harriss-White, Alexander and Wyeth, Dercon). However, it is clearly only a limiting case of the efficient arbitrage condition in (1), excluding situations in which no profitable trade can take place and markets in which conditions change sufficiently to allow a reversal of the trade flow. In this sense, finding cointegration is not sufficient for efficient arbitrage. Furthermore, the market efficiency of the outcome -whether the outcome is consistent with perfectly competitive markets- can not be addressed, unless long-run margins implied by (2) are assessed relative to actual transfer costs and other information about the markets.

The Parity Bounds Model provides an alternative statistical model for the analysis of market integration (Baulch)[2]. Assume that transaction costs have a constant mean (C^{ij}) and a random component u^c_t which is assumed to be normally distributed with zero mean and constant variance. The price differential $|P^i_t - P^j_t|$ can take three possible regimes in this specification. It can be inside the parity bounds, in which case $|P^i_t - P^j_t| = C^{ij}_t - u^I_t$; on the

2 Sexton, Kling and Carman use a similar set-up, but they assume the error terms u^I_t and u^O_t have the same variance.

parity bounds, when $|P^i_t - P^j_t| = C^{ij}_t$; or outside the parity bounds, when $|P^i_t - P^j_t| = C^{ij}_t + u^O_t$. The additional two error terms u^I_t and u^O_t are assumed two be independently and half normally distributed, truncated from above at zero, with constant variances. The likelihood function for the three regimes can then be specified and at the maximum, the probability of being in each of the three regimes, as well as the three variances and an estimate for C^{ij} can be found. In this case, identification occurs via the distributional assumptions. Consequently, they need to be reasonable for the problem considered. Sexton, Kling and Carman have information about trade flows, so that for periods on non-zero trade, one knows for certain that the markets are interconnected with flows in a particular direction. The efficiency of the arbitrage can be judged by the extent to which the actual margin is inside the parity bound (too much trade) and outside the parity bound (too little trade so that profitable trade opportunities remain unexploited) over time. The assumption of a half-normal distribution for the deviations from the parity may then appear quite reasonable, since there is a higher density of small errors relative to large errors. Nevertheless, the assumption of independent errors is harder to understand, since then the information contained in errors in one period is entirely lost in the next period - i.e. there is no process of adjustment to arbitrage errors. Finally, the efficiency of the market could be assessed if more information is available about actual transfer costs to compare this with the estimate of C^{ij}.

Baulch uses a similar model as Sexton, Kling and Carman, but introduces explicitly data on transfer costs, improving identification. It provides a more direct market efficiency interpretation, provided the transfer costs are comprehensive (Barrett). He does not include information on trade flows in his analysis and he re-interprets the regime inside the parity bounds somewhat differently. For him, this corresponds to the situation of a discontinuity in trade, in which no profitable trade could take place, not because of ‘errors’ by traders trading too much as in Sexton, Kling and Carman, but simply because transfer costs are too high for profits to be possible, so that no actual trade takes place. In this case, the assumption of a half-normal distribution inside the parity bounds is rather surprising, since it implies a higher density near the parity bound, even though the markets are not connected at that moment in time[3].

---

[3] Since inside the bounds the prices in i and j are unrelated, an identical distribution of the error inside the parity bound, or a random walk for the margin would be more realistic.

A THRESHOLD COINTEGRATION MODEL OF MARKET INTEGRATION

Suppose that as is usually the case, (real) prices in market j and i are non-stationary. Suppose further that real transfer costs to move grain between markets i and j are equal to C^{ij} in each direction[4], and constant over time (which will later on be relaxed). To derive an alternative model that could address some of the shortcomings of other approaches, let us define the margin between the price in i and j as:

$$m_t = P_t^i - P_t^j \tag{3}$$

Suppose that for the time being we have no information about trade flows nor about transaction costs. We can distinguish three regimes: $m_t > C^{ij}$, $m_t < -C^{ij}$ and $|m_t| \leq C^{ij}$. The last regime corresponds to (1), the condition for efficient spatial arbitrage, and consists of both situations in which trade occurs and arbitrage is efficient, and situations in which no profitable trade occurs. In the first (second) regime, market traders have not exploited profitable trade opportunities, in moving grain from i to j (j to i).

If arbitrage takes place, however slowly, then m_t would in the long run be a process returning to a band $[-C^{ij}, C^{ij}]$. Arbitrage will only happen outside this band until the threshold values on the band are reached. Even though m_t does not return to a particular equilibrium level but a to a band, m_t is a stationary process (Balke and Fomby). A threshold cointegration model and in particular the Band-Threshold Autoregression Model (Band-TAR) provides a reasonable way to characterise the behaviour of the actual margin m_t (Prakash and Taylor, Obstfeld and Taylor, Balke and Fomby). A version of the model can be specified as follows. Inside the parity bounds, when arbitrage is efficient, there is no arbitrage and the price gap shows no central tendency. When outside the parity bounds, arbitrage takes place and, just as in PPP or error correction models, there will be some non-linear autoregressive process to return to the long run band, and the size of the adjustment is a percentage of the deviation in each period. Formally, defining $\Delta m_t = m_t - m_{t-1}$, we can write this process as:

4 There is no statistical reason to restrict the model to symmetric transport costs, i.e. that $C^{ij} = C^{ji}$, as is assumed here. For example, if one suspects that backloading is possible in trade, then transfer costs may depend on the direction of trade. We do not discuss this possibility in our analysis, but all the algorithms used can be straighforwardly amended to estimate the model in this case (Balke and Fomby). We did test this possibility in the data to the extent the small sample size allowed us to do so. We could not find any evidence of asymmetries in thresholds (see footnote 10 below).

$$\Delta m_t = \begin{cases} r.\left(m_{t-1} - C^{ij}\right) + h_t^{out} & m_{t-1} > C^{ij} \\ h_t^{in} & \text{if} \quad \left|m_{t-1}\right| \le C^{ij} \\ r.\left(m_{t-1} + C^{ij}\right) + h_t^{out} & m_{t-1} < -C^{ij} \end{cases} \qquad (4)$$

where the errors are white noise, i.e. h_t^{out} is $N(0,\sigma_{out}^2)$ and h_t^{in} is $N(0,\sigma_{in}^2)$; ρ is the speed of adjustment of m_t towards the band $[-C^{ij}, C^{ij}]$[5]. The value of ρ is expected to be in the half open interval]0, -1][6]. Inside the band, there is no adjustment: the margin follows a random walk. Note that in this model, even though m_t is globally stationary, locally, i.e. inside the band, it displays unit root behaviour.

The link with error-correction models can be seen very clearly if we re-write (4) using (3):

$$\begin{cases} \Delta P_t^i = \Delta P_t^j + r.\left(P_{t-1}^i - P_{t-1}^j - C^{ij}\right) + h_t^{out} & P_t^i - P_t^j > C^{ij} \\ \Delta P_t^i = \Delta P_t^j + h_t^{in} & \text{if} \quad \left|P_t^i - P_t^j\right| \le C^{ij} \\ \Delta P_t^j = \Delta P_t^i + r.\left(P_{t-1}^j - P_{t-1}^i - C^{ij}\right) - h_t^{out} & P_t^j - P_t^i > C^{ij} \end{cases} \qquad (5)$$

Inside the band, there is no systematic dynamic relationship between changes in prices in each market. However, outside the band, error-correction behaviour can be observed. Changes in one market are only passed on with error to the other market, but there is a process of correction: in each period, part of the error is corrected. Similar to previous error-correction model based analysis for market integration, a natural measure of the how well markets are integrated for given transfer costs and given the existence of a long-run (band) equilibrium, is the speed of adjustment ρ: the closer to minus one, the better markets are integrated.

Equations (4) and (5) also show very clearly the subtle relationship between cointegration and efficient arbitrage. If efficient arbitrage takes place, unit root behaviour in price margins should be observed. This regime includes margins up to and including the parity bound; only when imperfect arbitrage takes place, we will observe cointegration and the error-correction formulation to be correct. Note that this is consistent with a standard result in financial

---

5 The model could be easily generalised by allowing for further lags in m and by allowing ρ and η^{out} to be different depending on whether $m_{t-1} > C^{ij}$ or $m_{t-1} < -C^{ij}$. The estimation technique remains unchanged.

6 ρ is expected to be zero if C^{ij} is sufficiently large not to allow ever any trade to take place or if never any scope for profitable arbitrage can be observed. In general, if the markets are not connected for whatever reason (market imperfections or high transfer costs), then ρ is expected to be zero.

market analysis without transaction costs, in which (informational) efficiency could be tested via the absence of cointegration[7]. The reason is that cointegration implies at least one Granger-causal relationship, so that profits in at least one market could be made via predicting prices using past prices (Engle and Granger, Granger and Escribano).

In conclusion, the Band-TAR is clearly consistent with efficient spatial arbitrage models: it allows for trade discontinuities and for trade flow reversals, just as the Parity Bounds Model. However, it uses more reasonable distributional assumptions and is dynamic, not static, explicitly considering the process of arbitrage in the form of a non-linear error-correction. The model given is a simple version of the Band-TAR model. Balke and Fomby give extensions in terms of a more complicated lag-structure, different adjustment speeds depending on the side of the price band, different threshold structure and other market equilibria.

ESTIMATING THE BAND-TAR

Even though locally the margin in this model is non-stationary, overall it is stationary, provided ρ is non-zero. Of course, stationarity will need to be tested. Balke and Fomby use Monte Carlo simulations to investigate the power of a large number of tests and find that standard tests for cointegration, such the ADF or the Phillips-Perron tests still have reasonably high power, even if the true model is a TAR[8]. Stationarity of the margin is evidence of interconnectedness: at least in the long-run the markets are integrated.

Once stationarity of the margin is established, one can proceed with the estimation of the Band-TAR model. The strategy is to estimate the model using a grid search over different possible values for the threshold. The basic tool is an arranged autoregression. In our application, this orders the data according to the values of Δm_t rather than by time. Note, however, that the dynamic relationship between m_t and its lags is retained; only the order of the observations is different. The sample is then partitioned is two sub-samples, one with all observations inside the band and one with all the observations outside the band. Next, one

[7] New information is immediately absorbed by all markets, so never any scope for arbitrage (i.e. short run errors) should be observed.

[8] The superconsistency results related to estimates of the cointegrating vector can be shown to apply as well. Even though no inference is possible on these estimates, in this stage the assumption of constant additive (i.e. non-proportional) transfer costs as assumed in the model could be looked into, by checking whether the coefficient on the other price in the cointegrating relationship is close to one (Palaskas and Harriss-White, Dercon).

has to choose a criterion, either to maximise the likelihood function of the TAR model (as in Prakash, in Prakash and Taylor and in Obstfeld and Taylor), or to maximise the sum of the residual sum of squared errors in each of the sub-samples (Balke and Fomby). Given the piece-wise linearity of the model outside the band and the unit root behaviour inside the band, either method is efficient and equivalent. These procedures return (super-consistent) estimates of the threshold (C^{ij}) (Chan) and the adjustment speed.

The estimated threshold provides an estimate of the margin used in trade. Comparing it with information about actual transfer costs could form the basis of further analysis on the efficiency of the market. Unfortunately, it is at present not clear how inference about the estimated thresholds might be conducted in practice, since there is no standard error available for this parameter (Balke and Fomby). Functional form tests could be used to check whether these thresholds are indeed present, i.e. for the presence of transactions costs. In general, the power of tests (including the cointegration tests preceding the analysis) can be shown to diminish if the ratio $\frac{(C^{ij})^2}{s^2_{m^T}}$ increases, i.e. the larger the transfer costs in relationship to the observed variability in the margin over the sample.

The model assumes a random walk inside the band, but this assumption can also be tested. In the application, we will estimate a more general model, nesting a unit root test within the threshold bands. In particular, the model estimated will be:

$$\Delta m_t = \begin{cases} r.(m_{t-1} - C^{ij}) + h_t^{out} & m_{t-1} > C^{ij} \\ l.m_{t-1} + h_t^{in} & if \quad |m_{t-1}| \le C^{ij} \\ r.(m_{t-1} + C^{ij}) + h_t^{out} & m_{t-1} < -C^{ij} \end{cases} \quad (6)$$

in which λ should be zero if inside the thresholds unit root behaviour takes place. A DF-test (or alternative unit root test) is used to test this.

Measures of the degree of market integration are straightforwardly derived from the analysis. The estimated value of the adjustment speed ρ gives the speed with which arbitrage restores equilibrium when profitable trade opportunities exist. The closer to minus one, the faster the adjustment. If the estimate is statistically not different from minus one, integration can be said to occur in the short run. This is not equivalent to ‘efficient arbitrage’, since errors are made; the point is that any errors observed in period t-1 are fully corrected by t: adjustment occurs faster than one time period in the data. A simple way to express the adjustment speed is in the context of an AR(1) model is by calculating a half life, which in our case is the time that is needed to correct half the error in the price margin relative to the long-run equilibrium. Another measure that can be derived is the percentage of cases in the sample in which the efficient arbitrage conditions are violated, i.e. the frequency of being outside the parity bounds. This measure bears some similarity to measures obtained in the Parity Bounds Model as will be discussed in the application below.

INTRODUCING INFORMATION ABOUT TRANSFER COSTS AND TRADE FLOWS

Up to now, we assumed that we had no information about transfer costs or trade flows, i.e. in Barrett's terminology, we were performing level I market analysis. How could information about transfer costs be introduced in this analysis? If the analysis is done in real prices and if constant real transfer costs are a reasonable assumption, one could at least compare estimated transfer costs with actual observed costs. Since there are good reasons to expect actual observed costs to be underestimating true costs - for example, they tend to exclude risk premiums, elements of sunk costs, etc. - then this may be the most sensible approach.

Suppose however that transfer costs C^{ij}_t are variable, for example due to seasonal factors or being dependent on behaviour of fuel prices over time, and that information is available on them (Level II market analysis.) The model can then be straightforwardly extended to:

$$\Delta m_t = \begin{cases} \Delta C^{ij}_t + r.\left(m_{t-1} - C^{ij}_{t-1} - q\right) + h^{out}_t & \quad m_{t-1} > C^{ij}_{t-1} + q \\ \Delta C^{ij}_t + h^{in}_t & \quad if \quad \left|m_{t-1}\right| \le C^{ij}_{t-1} + q \\ -\Delta C^{ij}_t + r.\left(m_{t-1} + C^{ij}_{t-1} + q\right) + h^{out}_t & \quad m_{t-1} < -(C^{ij}_{t-1} + q) \end{cases} \qquad (7)$$

If observed transfer costs are non-stationary, then in the first stage, cointegration will need to be tested between prices and transfer costs. If cointegration is not rejected, then (7) can be estimated using the same procedure as before. The resulting estimates on ρ can be interpreted in exactly the same way as before. The estimates of θ provide further information about the functioning of the markets. In particular, if θ is positive, then this may suggest inefficiencies in the market: estimated transfer costs implied by the analysis are actually larger than ‘true’ costs, so there may be problems with competition and entry in the market. Alternatively, the observed costs may not take into account all actual costs. Note that inference is unfortunately not possible on θ when standard estimation techniques are used.

If information on trade flows is available, further interpretation may be possible, even though the modelling strategy remains as in (4) or in (7). In periods in which trade flows are observed, we know for certain that the markets are connected. The issue reduces to how well they are connected. Note that the presence of trade flows could be consistent with both being on the parity bounds (i.e. in the regime when the efficient arbitrage condition is satisfied) and outside the bounds. Consequently, one could derive measures of the percentage of cases in which trade actually occurs to result in perfectly efficient arbitrage. In other words, one can distinguish cases, consistent with the spatial market equilibrium conditions, in which trade is simply not profitable from periods in which the markets perform efficient arbitrage.

Finally, examples have in recent years appeared in the literature in which either error-correction models (Dercon) or Parity Bounds Models (Rozelle, Park, Huang and Jin) have been used to discuss issues of liberalisation in markets, by looking at changes in transfer costs and in adjustment speeds over time. It should be clear that the Band-TAR model could be used in exactly the same way, by partitioning samples in specific time-periods or by considering tests of structural change. Note that just as in all other applications, given the non-stationary nature of the underlying series and parts of the Band-TAR model, and the increasingly small sample size, possibilities for inference, the power of the tests and the scope for interpretation will become rather limited.

APPLICATION TO MARKETS IN THE PHILIPPINES

We will now apply the model to the same data for rice markets in the Philippines as used by Baulch. Since he analysed the data using a large number of different techniques, including the Parity Bounds Model, this will allow us to illustrate better the differences in results using the Band-TAR. Another study (Silvapulle and Jayasuriya) analysed a selection of the markets considered as well, providing further room for comparison. The prices are monthly average wholesale prices for special-grade rice collected by the Philippine Bureau of Agricultural Statistics between January 1980 and June 1993. We deflated them using the All

Philippine CPI and express them into 1990 real prices. We assume constant transfer costs in real terms and initially we assume that we have no information on them.

We will consider eight trade routes, four of which including Manila, two others including Western Visayas and one linking Central Visayas with Mindanao. Region II (Northern Luzon) is a surplus area, supplying Metro Manila via overland routes, as is to a lesser extent Region III (Central Luzon). Manila is also an important port for inter-island trade. Region VI (Western Visayas) supplies the rest of the Visayas (including Region VII), as well as parts of Mindanao (such as Region IX) using sea transport. A number of shipping lines compete on all the major inter-island routes, except for the line between Iliolo (Region VI) and Cebu (Region VII) on which there is a monopoly. Shipping freight rates are regulated. Road transport is quite free of government regulation and costs vary mainly according to the type of roads. Further details on these markets can be found in Baulch and in Silvapulle and Jayasuriya.

First, all price series are found to be non-stationary in levels, but stationary in differences. Furthermore, all market pairs considered are cointegrated at least at 10 percent. Generally, the coefficients on prices are not far from one, so this is consistent with long-run connectedness with constant real transfer costs. Next, we estimated a Band-TAR model as in (6). We obtained estimates for the thresholds and for the adjustment speed outside the band (ρ_{out}). For comparison, we estimated a version of an AR(1) model on the residuals of the cointegrating relationship, e_t, i.e.

$$\Delta e_t = r \, . \, e_{t-1} + h_t \tag{8}$$

Effectively, this model assumes that there is never a discontinuity nor a trade flow reversal in the market, i.e. one is always at one side above the parity bounds. Note also that the estimate for ρ in (8) could equivalently be obtained from an error-correction model of prices with no lags. The adjustment speed is then the one usually reported in market integration studies using the error-correction models, and provides a basis for comparison with the Band-TAR estimates.

A useful way of interpreting the adjustment speed is to calculate the half-life implied by the estimates, i.e. the time that is needed for a variable to return to half its initial value - a measure of how fast errors are corrected[9]. Since immediate correction of any error is equivalent to ρ equal to minus one, we report a simple t-test of this hypothesis. In table 1 we provide the results from the Band-TAR model (4), in particular, the thresholds, the estimate for ρ_{out} and the implied half-life[10]. For comparison, we provide the results from (8), using the error from the cointegrating relationship. We also give the DF-test on whether the inside regime displays a unit root, using (6).

For three market pairs, some adjustment process towards the threshold can be detected inside the band $[-C^{ij}, C^{ij}]$. This can be interpreted as evidence of 'errors' by traders, similar too Sexton, Kling and Carman: too much rice being supplied by traders, resulting in temporary negative profits, with a correction in subsequent periods[11]. For all the other market pairs, the Band-TAR model with unit root cannot be rejected, even at 1 percent.

The estimated thresholds are generally in line with expectations. The route between region II and Manila has a relatively high threshold, probably linked to the higher costs of overland transport. The relatively high threshold between region VI and Manila is remarkable, possibly suggesting some market inefficiencies.

---

9 A half life is the solution for T in x(t+T)=x(t)/2. It can be shown that T=ln(1/2)/ln(b), with b=1+Δx(t)/x(t-1), or in our case, b=1+ρ. If ρ is -0.5, then T is one, so it takes one month to correct half the shock. In the limit, when ρ approaches -1, any error in t-1 is fully corrected in t.

10 We also investigated a further series of hypotheses. First, whether the estimated thresholds are different over time, by estimating the first half and the second half of the time series separately. Although we found some differences, they were relatively small and qualitatively similar. Note that inference on the thresholds is not possible. Secondly, we investigated whether there is any evidence of asymmetric thresholds. This could for example be due to back loading. We cannot find any evidence for this in the data, although in this case the optimisation is hindered by having to perform the estimates on at times very small sample sizes. This is less of a problem with symmetric thresholds, since restrictions can be imposed on the coefficients in both outer regimes. A Gauss program with the algorithms used for the calculations in this paper can be obtained from the authors.

11 For these three markets, we report in table 1 the estimates for the thresholds and the adjustment speed in the outside regime from (6), not (4).

Table 1: Transfer costs thresholds and adjustment speed in rice markets in the Philippines

Market pair	Band-TAR model (4)				Simple error-correction model (8)	
	Threshold (C^{ij})	Adjustment speed (ρ_{out})°	Half-life	DF-test on inside regime	Adjustment speed (ρ)	Half-life
Region II – Manila	0.94	-0.62 (0.17)*	0.71	-1.25	-0.24 (0.05)	2.59
Region III – Manila^	0.70	-0.36 (0.12)	1.57	-3.84^	-0.17 (0.04)	3.71
Manila – region VII^	0.39	-0.47 (0.09)	1.09	-2.80^	-0.37 (0.06)	1.48
Region VI – Manila	1.14	-1.07 (0.16)**	0.00	-1.17	-0.32 (0.06)	1.78
Region VI – region VII	0.65	-0.22 (0.06)	2.79	1.88	-0.30 (0.06)	1.95
Region VI – region IX	0.60	-0.48 (0.11)	1.06	-2.24	-0.34 (0.06)	1.66
Region XI – region VII	0.69	-0.51 (0.13)	0.97	-1.31	-0.26 (0.05)	2.34
Region VII – region IX^	0.99	-0.23 (0.12)	2.71	-3.39^	-0.19 (0.05)	3.34

° standard errors in brackets
* equality to -1 cannot be rejected at 5 percent
** equality to -1 cannot be rejected at 1 percent
^ unit root test on Band-TAR model (6) not rejected at 1 percent; results given are for outside regime from estimating (6)

On some of the routes, adjustment to long run threshold equilibrium is relatively fast: between region II and Manila, and between region VI and Manila, the adjustment speed is insignificantly different from minus one, i.e. adjustment occurs within one month (a half-life of zero). This result is equivalent to integration in the short run: arbitrage opportunities persist for less than a month in these two market pairs. On other routes, this speed of adjustment is lower: in four markets with a half-life of about 1-1.5 months. In two market pairs, adjustment is very sluggish with a half-life of more than 2.5 months.

It is instructive to compare these results with those from the error-correction model. Effectively, if the Band-TAR is correct, then the error-correction model would have been misspecified. In all but one case, the speed of adjustment estimated in the latter model is much higher. It is especially striking in those cases in which within-one-month adjustment was found in the Band-TAR: half-lives for these pairs in the error-correction model are close to 2 months or more. In general, prices are adjusting much faster than standard error-correction techniques would have suggested.

Table 2 gives the percentages of cases in the different possible regimes. As can be seen, in three out of the eight market pairs, we observe potential trade flow reversals, although the percentages involved are small. Regime 2, in which no arbitrage opportunities persist, occurs very often in all markets: in four out of eight markets the efficient market conditions are satisfied in more than 80 percent of cases. In only two cases, less than 60 percent of observations are in regime 2. In other words, even if at times trade opportunities are not fully exploited, most markets are very often in this situation. Note that this regime could be consistent with efficient arbitrage via trade or with zero trade flows because of unprofitable trade. Only with trade flow data can we interpret this result further.

To conclude, we appear to be finding that despite being perfectly integrated in the long run, arbitrage opportunities remain quite often. For some market pairs we find only sluggish adjustment to the long-run equilibrium. In other words, markets are not integrated in the short run, with the exception of the large supply route between region II and Manila, and the link between Manila and Region VI. Nevertheless, for the majority of markets, the efficient arbitrage market conditions are satisfied for more than 80 percent of the cases. Without detailed information about actual trade flows, we cannot interpret the results in regime 2 as reflecting trade discontinuity or perfect arbitrage efficiency. Also, without more information about actual transfer costs, we cannot derive strong conclusions about the allocational efficiency of the trade routes in the long run.

Table 2: Percentage of cases of markets outside and inside bands

	Regime 1 (profitable trade from first region possible)	Regime 2 (inside band; no arbitrage opportunities)	Regime 3 (profitable trade from second to first region possible)
Region II-Manila	19	81	0
Region III-Manila	2	86	12
Manila-region VII	43	52	5
Region VI-Manila	15	85	0
Region VI-region VII	65	35	<1
Region VI-region IX	35	64	<1
Region XI – region VII	27	73	0
Region VII-region IX	0	91	9

Some incomplete evidence is available on both issues. For the route between Iliolo (Region VI) and Manila, Baulch estimated a minimum transport cost margin of about 0.36 per kg in real 1990 prices[12]. The estimated threshold in table 1 appears to be higher, suggesting some problems with competition on this route (despite fast adjustment)[13]. On another route, between Iloilo and Cebu (Region VII) the estimated transport costs are 0.51 per kg, close to the estimated margin. This is an interesting result: in the long run, margins relative to transport costs appear quite close, suggesting no excessive profit rates related to rice market imperfections. Nevertheless, the adjustment in this market is very slow. They are likely to be linked to the monopoly on transport enjoyed by Trans Asia Lines on this route: they only allow pattetised transport, pushing up transport costs and effectively imposing at quantity constraints on the amounts that can be shipped.

Another issue, the extent of the inefficiency in arbitrage (relative to a given estimate of the threshold) can also be looked at in more detail. In table 3, we present the mean excess profits that remain unexploited when in regime 1 or in regime 3 in each market pair, given a

---

[12] This is a lower bound of total transfer costs, since it applies only for container transport costs. While cheaper than palletised transport, it requires large volumes of trade, not necessarily suitable for large traders. It excludes other aspects of transfer costs. For example, to obtain a container side-payments are often required. Palleted transport is usually more than twice as expensive.

[13] As in Faminow and Benson, relatively fast arbitrage, implying short-run integration, could be consistent with inefficiencies in the market with super-normal profits from trade and a lack of contestability of the market.

particular long-run transfer margin. In other words, it gives an idea of the typical gains from trade through arbitrage.

Table 3: Mean excess profits by regime (1990 prices)

	Excess profits in regime 1 (profitable arbitrage possible from first to second named market)		Excess profits in regime 3 (profitable arbitrage possible from second to first named market)	
	Mean	as % of mean price in first market	Mean*	as % of mean price in second market
Region II-Manila	0.26	3.1		
Region III-Manila	0.10	1.1	0.42	4.7
Manila-region VII	0.31	3.5	0.26	2.8
Region VI-Manila	0.31	3.7		
Region VI-region VII	0.46	5.5		
Region VI-region IX	0.36	4.3		
Region XI – region VII	0.28	3.2		
Region VII-region IX	0.18	2.0	0.48	5.4

* Empty cells for markets with zero or a very small number of observations.

Generally, these potential gains from arbitrage are very similar in all markets, between 1 and 5.5 percent of the market price in supply market. Although they suggest quite a substantial source of potential profits, they can hardly be considered a sign of very poor arbitrage. Indeed, given measurement error and slight differences in quality, it may well imply relatively well-functioning markets, even if the evidence in table 2 suggests sluggish adjustment to exploit these excess profits. Also, the lower transport costs involved in containerised transport, introduces a certain lumpiness in profitable trading in practice, so that traders may not consider small deviations of actual margins from the long-run equilibrium worth trading for. It is nevertheless striking that the route from region VI to region VII, a very important trade route, has the one of the largest unexploited margins at more than 5 percent on average. This further supports the interpretation of the earlier results that the monopoly in transport is causing inefficient arbitrage.

For one year, 1984, we have information on some of the monthly trade flows between markets. In table 4, they are presented, as well as the frequency of price margins inside the estimated parity bounds (i.e. regime 2) in 1984 and in the entire sample period. The flow of rice between Manila and region VII was in 1984 year the largest of those given here, followed by the flow from Region VI to Region VII; much smaller flows occurred from Region VI to Region IX and especially to Manila. There are also important fluctuations in the level of flows, with the smallest flows in May to September except for on the Manila to Region VII, where the lowest flows were later in the year. Discontinuities in trade and virtually zero flows also regularly happen in all routes.

In the estimations, we found that in 1984, the Region VI to Manila route was consistent with efficient arbitrage conditions, i.e. in regime 2, and this was the most common outcome in all years. However, in at least five months, it is reflecting a discontinuity of trade, while in the other months it is consistent with efficient arbitrage through trade, albeit with very small trade flows. Note that this is consistent with the earlier results: on this route any scope for arbitrage is very speedily corrected (within one month). These markets appear to be following each other very closely, and any arbitrage opportunities are very quickly exploited, regularly resulting in perfectly efficient arbitrage. Note nevertheless that the estimated threshold was relatively large, so that despite relatively efficient arbitrage, market imperfections and above normal profits may still be present.

The trade route between Region VI and IX also has regularly price margins consistent with efficient arbitrage, in 1984 in two-thirds of the months. Often they coincide with trade taking place (even though with relatively small flows), suggesting arbitrage efficiency, although in at least one month, no trade occurred despite possibilities for profits remaining unexploited. Note that according to table 1, this market pair has a relatively high adjustment speed as well, consistent with relatively high arbitrage efficiency.

The picture for the trade routes from Region VI and from Manila to Region VII give a different picture. Substantial flows take place in the direction of Region VII in most periods. Despite this, in 1984 virtually never were the efficient arbitrage conditions satisfied, especially between Region VI and VII. In other years, in many months this result applied as well. This provides further evidence on the limited arbitrage efficiency on the latter trade route.

Table 4: Trade flows and the frequency of regime 2

	Region VI-Manila			Region VI-region VII			Manila – Region VII			Region VI- Region IX		
	times inside band 1980-92 (out of 13)	flow in 84 (range in '000 tons)	regime in 1984	times inside band 1980-92 (out of 13)	flow in 84 (range in '000 tons)	regime in 1984	times inside band 1980-92 (out of 13)	flow in 84 (range in '000 tons)	regime in 1984	times inside band 1980-92 (out of 13)	flow in 84 (range in '000 tons)	regime in 1984
January	12	0-1	2	5	1-2	2	6	3-4	2	10	0-1	2
February	11	0-1	2	2	5-6	1	6	0-1	1	11	1-2	2
March	11	0-1	2	5	6-7	1	7	2-3	1	12	1-2	2
April	11	0-1	2	6	3-4	1	6	5-6	1	11	0-1	2
May	13	0	2	9	0	1	9	4-5	2	10	0	1
June	13	0	2	7	1-2	1	7	4-5	2	12	0-1	2
July	13	0	2	8	1-2	1	6	3-4	2	9	0-1	1
August	13	0	2	7	1-2	1	8	2-3	1	8	1-2	1
September	11	0	2	5	5-6	1	8	0-1	1	6	0-1	1
October	11	1-2	2	1	6-7	1	7	0-1	1	7	1-2	2
November	10	0-1	2	1	7-8	1	3	0-1	1	9	1-2	2
December	10	0-1	2	4	2-3	1	3	1-2	1	10	1-2	2

CONCLUSION

In this paper, we presented an approach to market integration analysis that builds on cointegration analysis, but that is able to allow for discontinuities and trade reversals. We have shown that all the results derived from the standard cointegration analysis, as well as approaches using a switching regression model, can be nested in a Band-TAR model and estimated using threshold cointegration techniques. We applied the model to data from Philippine rice markets. We find that in the long-run, these markets are interconnected. We also find in a few markets speedy adjustment consistent with short-run integration within one month, but not in all markets. Arbitrage inefficiencies appear quite common, although for half the market pairs considered, arbitrage efficiency has been found in more than 80 percent of the months considered. Trade discontinuities appear quite common, as reflected in the estimations as well as in limited data on trade flows available; trade reversals are rare.

Using the trade flow data, we find that in most markets achieve regularly full arbitrage efficiency with trade taking place; in others, profits remain unexploited and arbitrage is slow and rather inefficient. Especially the results on the trade relationship between Region VI and VII stand out. Although the estimated threshold appears not excessively high, adjustment is slow and unexploited profits are high. Despite this, trade flows appear rather low. Contrary to most other main routes, one shipping company has a monopoly on this line and does not allow containers on this route. This may well cause an important inefficiency.

Since we use the same data, how do the results compare with Baulch? He states that “the results indicate that Philippine rice markets are integrated within a single data period almost 100 percent of the time” (pp.485). Also, “that the model detects efficient spatial arbitrage in situations were conventional tests fail to do so because of the existence of discontinuous trade flows”. As was argued before, allowing discontinuous trade is indeed an important contribution of the Parity Bounds Model, compared to conventional tests. But how can we square these findings with the result that despite regular discontinuities, efficient spatial arbitrage conditions are regularly violated, as in our results? All depends on what is actually assumed when the market is called ‘efficient’. In his application, Baulch assumes constant real transfer costs with a random error. The error is explicitly attributed to the transfer costs, i.e. they are assumed to be measured with error or have a stochastic shock, while the prices are correctly observed. So, efficient arbitrage applies when trade occurs *and* when the price differential is equal to the transfer costs, the latter including a stochastic element. In other words, the margin deviates often from the measured long run real transfer costs, even under the efficient arbitrage regime. In this regime, the margin follows a stationary normally distributed process around the (measured) transfer costs – transfer costs have a non-persistent stochastic part. Of course, if we do not interpret it as measurement error, but as actual errors in the market - too little or too much trade, as in Sexton, Kling and Carman - then we are much closer to the 'long-run' results in cointegration analysis: in the short-run, errors are made, but they do not persist. It is efficient arbitrage with errors in the short-run, but not in the long-run. The fact that, in Baulch, in most cases this condition is satisfied using the same data, except in cases when the margin becomes very small, is consistent with cointegration, i.e. long-run integration. But given that errors are being made, it is hard to argue that this regime is actually representing perfectly efficient arbitrage, especially since no further testing of the dynamic properties of the errors is presented. Without modelling the lag structure of the error process, it is hard to see how it can be argued that markets are integrated within one month.

In the Band-TAR, another extreme position is taken regarding whether efficient spatial arbitrage takes place. In (2) and in the estimation, there is no allowance for possible measurement error in the data or for a stochastic element in the transfer costs. In particular, the threshold is estimated within the sample and cases are allocated to regimes very strictly on the basis of whether the measured margin is larger or smaller than this estimated threshold. For example, a very small positive deviation of the margin from the threshold results in the case to be allocated to the regime in which trade opportunities are not allowed. Consequently, since measurement error (or some random shock to transfer costs) are bound to occur, we probably overestimate the number of cases in which the efficient arbitrage conditions are violated. The fact that for most market pairs the mean excess profits (table 3) are relatively small suggests a substantial number of cases in which the extent of the violation of the conditions for efficient arbitrage is relatively limited[14]. Consequently, those market pairs for which the efficient arbitrage conditions were satisfied for most of time, could well be considered to be functioning rather well[15].

One important shortcoming of our approach, just as of standard cointegration analysis and the Parity Bounds Model, is that it focuses on relations between market pairs. Markets are obviously more complicated with different markets influencing each other. Multiple cointegration techniques are better able to take these into account. Silvapulle and Jayasuriya provide an application for several of the markets considered in this paper. However, the

---

14 Note also that in three market pairs we found a tendency of the process inside the band reverting to the threshold, which could be consistent with both 'errors' in trading or independently distributed measurement error.

15 Examples are the routes between Region II and Manila, Region III and Manila, Region VI and Manila and Region VII and Region IX.

econometrics of threshold vector error correction models, which would allow for discontinuities and flow reversals, are at present not well understood (Blake and Fomby), making their application to market integration analysis infeasible at present. Silvapulle and Jayasuriya could not reject a restriction imposed on the multiple cointegrating relationships in the Johansen and Juselius framework under the hypothesis that, in all market relations they considered, only Manila mattered in the long-run relationship[16]. Consequently, only modelling market pairs may not be incorrect for trade routes including Manila, as in four of the routes considered.

Finally, there are definitely aspects of this model that could be improved upon in future work. We can suggest two extensions. First, in the current model the adjustment process outside the band of thresholds is linear: the speed of adjustment is constant, irrespective of the extent of the deviation from long-run equilibrium. Alternative non-linear models could be considered, such as the STAR (Smooth Transition Autoregressive Model), suggested by Michael, Nobay and Peel for exchange rates or introducing higher order error-correction terms in the TAR. Since the estimated half-lives in our model appear relatively high, this may well be caused by this assumptions. Another extension would be to introduce stochastic thresholds, therefore dropping the strict assumption that all errors stem from price formation and not from stochastic elements in transfer costs.

---

16 Silvapulle and Jayasuriya use a different time period, but the results of their multiple error correction model show very similar results as those based on a pairwise error correction model (7). Estimates of the coefficients on the error-correction terms implied half-lives of similar magnitude as in the last column of table 1 (half-lives of 2 to 4 months). These half-lives do not justify their conclusion that errors in ‘the price differentials persist only short periods of time’ (p.378); rather, their results imply the opposite. Note that their model is not consistent with trade reversals or discontinuities.

REFERENCES

Alexander, C., and Wyeth, J., "Cointegration and Market Integration: An Application to the Indonesian Rice Market", *Journal of Development Studies*, Vol. 30, No. 2, pp. 303-328, January 1994.

Balke, N. S., Fomby, T. B., "Threshold Cointegration", *International Economic Review*, 1997.

Barrett, C. B., "Market Analysis Methods: Are Our Enriched Toolkits Well-Suited to Enlivened Markets?", *American Journal of Agricultural Economics*, 78, pp. 825-829, August 1996.

Baulch, B., "Transfer Costs, Spatial Arbitrage and Testing food Market Integration", *American Journal of Agricultural Economics* (79), pp. 477-487, May 1997.

Baulch, B., *Spatial Price Equilibrium and Food Market Integration*, Ph.D.Dissertation Food Research Institute, Stanford University, 1994.

Chan, K. S., "Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model", *The Annals of Statistics* 21, pp. 520-533, 1993.

Dercon, S., "On market integration and liberalisation: method and application to Ethiopia", *Journal of Development Studies*, Vol.32 no.1, pp.112-143, 1985.

Engle, R. F., Granger, W. J., "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*, Vol. 55, No. 2, pp. 251-276, 1987.

Fafchamps, M., Gavian, S., "The Spatial Integration of Livestock Markets in Niger", *Journal of African Economies*, 5(3): pp. 366-405, October 1996.

Goodwin, B. and Schroeder, T., "Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets", *American Journal of Agricultural Economics*, vol.73, no.2, pp.452-464, 1987.

Granger, C.W.J. and Escribano, A. "The Long-Run Relationship Between Prices from an Efficient Market: The Case of Gold and Silver", University of California, San Diego (mimeo), 1987.

Obstfeld, M., Taylor, A. M., "Nonlinear Aspects of Goods-Market Arbitrage and Adjustment: Heckscher's Commodity Points Revisited", NBER Working Paper (W6053), 30 p., June 1997.

Panos, M., Nobay, A.R. and D.A.Peel, "Transactions Costs and Nonlinear Adjustment in Real Exchange Rates: An Empirical Investigation", *Journal of Political Economy*, vol.105, no.4, 1997.

Palaskas, T., B., and Harris-White, B., "Testing Market Integration: New Approaches with Case Material from the West Bengal Food Economy", *Journal of Development Studies*, Vol. 30, No. 1, pp. 1-57, October 1993.

Prakash, G., "Pace of Market Integration", Northwestern University, 47 p., November 1996.

Prakash, G., Taylor, A. M., "Measuring Market Integration: A Model of Arbitrage with an Econometric Application to the Gold Standard, 1880-1913", NBER (WP 6073), June 1997.

Ravallion, M., "Testing Market Integration", *American Journal of Agricultural Economics*, pp. 102-109, 1986.

Rozelle, S., Park, A., Huang, J., and Jin, H., "Liberalisation and Rural Market Integration in *American Journal of Agricultural Economics* (79), pp. 635-642, May 1997.

Sexton, R. J., Kling, C. L., Carman, H. F., "Market Integration, Efficiency of Arbitrage, and Imperfect Competition: Methodology and Application to U.S. Celery", *American Journal of Agricultural Economics*, pp. 568-580, August 1991.

Silvapulle, P., Jayasuriya, S., "Testing for Philippines Rice Market Integration: A Multiple *Journal of Agricultural Economics*, vol.45, no.3, pp. 369-380, 1994.

Takayama, T., Judge, G. G., *Spatial and Temporal Price and Allocation Models,* Contributions to Economic Analysis 73, North-Holland Amsterdam, 528 p., 1971.

Table 1: Transfer costs thresholds and adjustment speed in rice markets in the Philippines

Market pair	Band-TAR model (4)			Band-TAR model (6)						Simple error-correction model (8)	
	Threshold (C^{ij})	Adjustment speed (ρ_{out})°	Half-life	Threshold (C^{ij})	Adjustment speed (ρ_{out})°	Half-life	Adjustment λ inside band	DF-test	Half-life	Adjustment speed (ρ)	Half-life
Region II - Manila	**0.94**	**-0.62 (0.17)***	**0.71**	0.92	-0.59 (0.17)*	0.77	-0.07	-1.25	10.00	-0.24 (0.05)	2.59
Region III - Manila	0.06	-0.23 (0.05)	2.69	**0.70**	**-0.36 (0.12)**	**1.57**	-0.32	-3.84	1.81	-0.17 (0.04)	3.71
Manila - region VII	0.08	-0.28 (0.06)	2.11	**0.39**	**-0.47 (0.09)**	**1.09**	-0.54	-2.80	0.88	-0.37 (0.06)	1.48
Region VI - Manila	**1.14**	**-1.07 (0.16)****	**0.00**	1.10	-1.00 (0.17)**	0.00	-0.08	-1.17	8.49	-0.32 (0.06)	1.78
Region VI - region VII	**0.65**	**-0.22 (0.06)**	**2.79**	0.63	-0.22 (0.06)	2.79	0.28	1.88^{+}	2.78	-0.30 (0.06)	1.95
Region VI - region IX	**0.60**	**-0.48 (0.11)**	**1.06**	1.02	-1.14 (0.34)**	0.00	-0.12	-2.24^{+}	5.34	-0.34 (0.06)	1.66
Region XI - region VII	**0.69**	**-0.51**	**(0.13)**	0.97	-1.00 (0.22)	0.00	-0.07	-1.31	9.84	-0.26 (0.05)	2.34
Region VII - region IX	0.05	-0.15 (0.05)	4.27	**0.99**	**-0.23 (0.12)**	**2.71**	-0.22	-3.39	2.77	-0.19 (0.05)	3.34

° standard errors in brackets

* equality to -1 cannot be rejected at 5 percent

** equality to -1 cannot be rejected at 1 percent

\+ unit root not rejected at 5 percent

++ unit root not rejected at 1 percent