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Rice markets in the Mekong River Delta, Vietnam : A market integration analysis

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1. Introduction

The process of market liberalization in Vietnam over the past 20 years has created a rapid growth in agriculture in general as well as in rice production in particular. The market reform has resulted in drastic changes in the rice market structure, the conduct, and the performance of the major rice production area in the South of Vietnam – the Mekong River Delta (Luu Than Duc Hai, 2003).

Regarding market performance, spatial price behaviour in regional rice markets is an important indicator of overall market performance. Markets that are not integrated may convey inaccurate price information distorting the marketing decisions of rice producers and contributing to inefficient product movements. Therefore, an important part of market performance analysis focuses on rice market integration between different market places.

In the case of Vietnam, the long distance between the North and the South draws attention to the issue of spatial price movements across the country. Therefore, rice market integration is studied to provide more details about the extent of price transmission across different locations within the country and some main cities that are located in the North and the South. This study attempts to assess the efficiency of the supplied market services by analyzing market integration across different locations and for different time periods in the major rice markets in Vietnam. With respect to the international level, this study also measures the integration of rice prices between Vietnam and Thailand.

2. Methodology

Several methods for measuring price integration have been used beginning with simple bivariate correlation coefficients. These coefficients were interpreted as a measure of how closely price movements of a commodity at different markets were linked. This is the simplest way to measure the spatial price relationships between two markets. However, this method clearly has some limitations, since it can not measure the direction of price integration between two markets (Lutz, 1994). One method for measuring the degree of price integration takes the above-mentioned critique into account: the co-integration procedure. This econometric technique provides more information than the correlation procedure, as it allows for the identification of both the integration process and its direction between two markets.

Regional prices move over time because of various shocks. If in the long run they exhibit a constant linear relation, then we say that they are co-integrated. In general, the presence of co-integration between two series is indicative of inter-dependence. In other words, co-integration indicates non-segmentation between the two series. Co-integration analysis is a useful tool to give an answer about the existence of a relation between two economic time-series.

The Johansen (1998) and Stock and Watson (1998) maximum likelihood estimators circumvent the use of two-step estimators and can estimate and test for the presence of multiple co-integrating vectors. Moreover, these tests allow the researcher to test restricted versions of the co-integrating vectors and the speed of adjustment parameters. This study mainly applies the Johansen procedure to test for long run and short run co-integration. To use the co-integration procedure, several steps need to be carried out on the price series: first, the Augmented Dickey Fuller test (ADF) and then the Johansen procedure.

3. The data and model specification

3.1. Time series data on price of rice

When spatial price integration is studied, the analysis should preferably be based on day-prices or at least average week-prices. It is clear that average month-prices may be very rough estimates of day-prices. Especially during periods of changing market relationships[2], these monthly averages may deviate substantially from market day-prices. Moreover, average month-prices are not the right variables to indicate the short-run price integration process. In Vietnam, day-prices are available for only a few market places and only for a short period in the past. Therefore, we use weekly price series, from 1998 to August 2001. Especially, the price series of 25 percent broken rice are used for the analysis, since this kind of rice is popular to consumers in the domestic rice markets. Nine major market places are chosen to analyse market integration. Of these, four markets are located in the Mekong River Delta (Angiang, Cantho, Soctrang, and Tiengiang), two markets are in the middle and central highland area (Lamdong, and Danang), and two are City markets (Ho Chi Minh City - HCM City for short - and Hanoi). Finally, the major export market at HCM City is also included in this analysis. The weekly price data were provided by the Cantho Trade Department, the Information Centre of the Ministry of Agriculture and Rural Development, and the Ministry of Trade of Vietnam.

3.2. The model specification

Mathematically, the starting point for a model for testing market integration based on multiple co-integrating vectors is the following:

$$x_t = A_1 x_{t-1} + A_2 x_{t-2} + \ldots + A_{p-1} x_{t-(p-1)} + A_p x_{t-p} + \varepsilon_t \qquad (1)$$

Where:

- t = 1, 2,….. refer to the weeks from 1998 to August 2001
- n is the number of markets included in the analysis
- p is a a priori unknown integer, its value has to be determined
- x_t is an (n x 1) vector of variables $(x_{1t}, x_{2t}, \ldots x_{nt})'$: [price of n market places]
- A_i is an (n x n) matrix of coefficients
- ε_t is an (n x 1) vector of error terms

With: $\Delta x_t = x_t - x_{t-1}$ equation (1) can be put in a more suitable form by replacing x_{t-k} by $x_{t-k-1} - \Delta x_{t-k-1}$:

$$\Delta x_t = \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \pi x_{t-1} + \varepsilon_t \qquad (2)$$

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[2] For example at the end of the off season and the beginning of the harvest season

where:

π and π_i are defined by

$$\pi = \left(\sum_{i=1}^{p} A_i - I \right)$$

$$\pi_i = -\sum_{j=i+1}^{p} A_j$$

Regressing Δx_t on Δx_{t-1}, ..,Δx_{t-p-1} and x_{t-1} yields an estimate for π. In this sense the Johansen test can be seen as a multivariate version of the Augmented Dickey-Fuller test for the existence of a unit root. If π has full rank, then all the elements of x_t are stationary, if π is zero, they all are integrated. In the intermediate case that π has a defective rank, its rank determines the number of independent co-integrating relations: linear combinations of the non-stationary elements of xt, that are stationary.

Johansen defines two matrices α and β, both of dimension (n x r), where r is the rank of π , such that:

$$\pi = \alpha \beta'$$

The matrix β is the matrix of co-integrating relations, and the matrix α is the matrix of weights with which each co-integrating vector enters the *n* equations of the vector error correction model (VECM). α can be viewed as the matrix of the speed of adjustment parameters as explained below. Due to the cross-equation restrictions and the fact that parameters enter the model in a non-linear way, it is not possible to estimate α and β using OLS. [3] However, with maximum likelihood estimation, it is possible to (i) estimate (1) as an error-correction model; (ii) determine the rank *r* of π; (iii) use the *r* most significant co-integrating vectors to form β'; and (iv) select α such that $\pi = \alpha\beta'$.

The equation for a single element now takes the form

$$\Delta x_{i,t} = ... + \alpha_{ij} \sum_k \beta_{kj} x_{k,t} + \varepsilon_{i.t}$$

where for notational simplicity, we have not written out the coefficients of the $\Delta x_{j,t-k}$. The linear combinations $\Sigma_k \beta_{kj} x_{k,t}$ are the co-integrating relations that occur in every equation, the coefficients α_{ij} determine the weight that these coefficients have in the equation. Interpreting the co-integrating relation $\Sigma_k \beta_{kj} x_{k,t}$ as a long term equilibrium relation, the α_{ij} can be seen as the influence that the deviations from the long term equilibrium have on the changes in x_i: a large value for α_{ij} shows a strong dependence on the long term equilibrium.

The Johansen procedure estimates the rank of π, by an iterative process, comparing the null of rank at most *r*, with the alternative of rank larger than *r.*

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[3] The Johansen procedure consists of the matrix of vectors of the squared canonical correlations between the residuals of x_t and Δx_{t-1} regressed on lagged values of Δx_t. The co-integrating vectors are the rows of the normalized eigenvectors (Enders, W. 1998).

4. Results of the test

Step 1: Pre-tests and lag length

We start by pre-testing all variables to assess their order of integration by an Augmented Dickey Fuller (ADF) test on a unit root:

$$\Delta x_t = \delta x_{t-1} + \sum_{k=1}^{p} \gamma_k \Delta x_{t-k}$$

Secondly, we continue to test for the lag length. The results of co-integration tests can be quite sensitive to lag length. An obvious procedure is to estimate a vector auto-regression (VAR) on the differenced series. Start with the longest lag length deemed reasonable and test whether the lag length can be shortened. We use the Akaike information criterion (AIC) and Schwarz criterion (SC) to select a suitable lag length.

Table 1 : Unit root test on rice price series in different market places in Vietnam

Market place	No. of observations	Unit root-test on price levels			Unit root-test on first differences		
		ADF [(1)]	δ	t-value [(2)]	ADF [(1)]	δ	t-value [(2)]
1. Angiang	188	ADF (2)	- 0.046	- 1.634	ADF (1)	- 1.517	- 13.064
2. Cantho	187	ADF (3)	- 0.025	- 1.151	ADF (2)	- 1.524	- 10.270
3. Danang	188	ADF (2)	- 0.002	- 0.081	ADF (1)	- 1.285	- 11.939
4. HCM City	188	ADF (2)	- 0.045	- 1.735	ADF (1)	- 1.383	- 12.486
5. Hanoi	188	ADF (2)	- 0.038	- 1.600	ADF (1)	- 1.414	- 12.646
6. Lamdong	185	ADF (5)	- 0.021	- 0.822	ADF (4)	- 1.905	- 9.195
7. Soctrang	188	ADF (2)	- 0.001	- 0.389	ADF (1)	- 1.339	- 12.417
8. Tiengiang	188	ADF (2)	- 0.022	- 1.024	ADF (1)	- 1.563	- 13.587
9. VN Export	186	ADF (1)	- 0.029	- 1.431	ADF (0)	- 1.315	- 18.800

Note: [(1)] In the column ADF the number of lags that was allowed for in the unit root test is indicated in brackets. No serial correlation was detected (5% significance level).
[(2)] Critical value are given in Maddala (1992, p.606): t = - 2.88, 5% level of significance.
Source: Weekly paddy and rice price series from 1998 to 2001. ADF analysis was carried out in EVIEWS © 4.0

Using the ADF test, the results presented in Table 1 indicate that the price series for the nine markets under study are I(1). For all the price series the unit root test shows that the coefficients of xt-1 are not significantly different from zero and so none of the price series is stationary. Furthermore, the unit root test on first differences confirms the opposite, which leads us to conclude that all series are integrated of order 1. This result implies that inclusion of first differences as variables in the model will eliminate the stochastic trend in the nominal series.

With respect to lag length, the result of the VAR analysis on first shows that the smallest value for both AIC and SC is obtained with lag length 1 (See Appendix 1). The result of the VAR analysis is presented in Table 2 below.

Table 2 : VAR analysis on rice price series in different market places

	∆VN(-1)	∆HCM(-1)	∆CT(-1)	∆LD(-1)	∆TG(-1)	∆HN(-1)	∆ST(-1)	∆AG(-1)	∆DN(-1)
∆VN	- 0.304 [-4.327]	-	-	-	-	-	-	-	-
∆HCM	0.169 [2.820]	-0.173 [-2.295]	0.247 [2.744]	-	-	-	-	-	-
∆CT	0.087 [1.870]	-0.148 [-2.257]	-0.298 [-3.846]	0.106 [1.873]	-	-	-	-	-
∆LD	0.145 [2.012]	-0.188 [2.074]	-	-0.196 [-2.481]	-	-0.159 [1.792]	-	-	-
∆TG	0.107 [1.820]	-	0.157 [1.813]	0.138 [2.154]	-0.267 [-3.644]	-	-	-	-
∆HN	-	0.158 [2.067]	-	-	-	-0.299 [-3.068]	-	-	-
∆ST	-	-	-	-	-	0.126 [1.761]	-0.158 [-1.763]	-	-
∆AG	-	-	-	-	-	0.148 [1.805]	-	-2.208 [-3.698]	-
∆DN	-	-	-	0.129 [2.070]	-	-	-	-	-0.178 [-2.406]

Note: The results of the VAR analysis are based on one lag (the AIC and SC are smallest).
All figures in parenthesis […] are t-values.

In general, Table 2 shows that the present price changes in all market places are highly correlated with their own price change in the previous period. The results in the first column indicate that the price changes in most major rice markets in the Mekong River Delta and HCM City are strongly related to changes in the export price (***∆VN***). Clearly, rice traders in Vietnam have to follow the price set in the international market. On the other hand price changes in the domestic market do not have any measurable influence on the export price, even though Vietnam is the world's second largest exporter of rice. The price series in the domestic market show that most markets within the Mekong River Delta and HCM City strongly cohere (HCM, CT, TG). The markets located in the center and in the north have a weak relationship with the other markets. This result may be explained by the transportation costs involved. There is a group of four markets: Cantho, Tiengiang, HCM City, and Lamdong that show a very strong correlation. Here, a major group of rice traders is located handling large amounts of rice in the domestic markets.

Step 2: Determine the number of co-integrating equations

The main task in this step is to determine the rank of π and estimate the co-integrating equations. By using the Johansen co-integration test, available in EVIEWS, we get the following results on λ_{trace} and λ_{max} to determine rank of π.

The results of λ_{trace} and λ_{max} using the Johansen co-integration test (Table 3) indicate that the rank of π can be set to 3 (for both the λ_{trace} and λ_{max} tests at 95% significant level).[4] It means that there are at least three co-integrating equations in our estimation.

[4] Because if we select $r \geq 4$ then the λ_{trace} and λ_{max} value are smaller than the 95% critical value (54.09<59.46 for λ_{trace} and 34.82<36.36 for λ_{max})

Table 3: The λ_{trace} and λ_{max} tests

Null Hypothesis	Alternative hypothesis		95% Critical value	99% Critical value
λ_{trace} tests		*λ_{trace} value*		
r = 0	*r > 0*	249.80	175.77	187.31
r ≤ 1	*r > 1*	184.10	141.20	152.32
r ≤ 2	*r > 2*	134.04	109.99	119.80
r ≤ 3	*r > 3*	88.91	82.49	90.45
r ≤ 4	*r > 4*	54.09	59.46	66.52
λ_{max} tests		*λ_{max} value*		
r = 0	*r = 1*	65.70	53.69	59.78
r = 1	*r = 2*	50.05	47.99	53.90
r = 2	*r = 3*	45.12	41.51	47.15
r = 3	*r = 4*	34.82	36.36	41.00
r = 4	*r = 5*	23.55	30.04	35.17

Note: If the value of λ_{trace} and or λ_{max} exceeds the critical value, we reject the null hypothesis and accept the alternative of more co-integrating vectors.

Step 3: Testing long-term price integration

We focus on the long-run co-integration of price series by analyzing the normalized co-integrating coefficients (β). To estimate co-integrating coefficients (β) we use the Johansen co-integration test as implemented in EVIEWS.

The co-integrating coefficients β estimated in step 2, r = 3 are presented in Appendix 2. If we normalize with respect to the export price of Vietnam (VN), and the prices in HCM City (HCM), and in Cantho (CT), the three normalized co-integrating equations are as follows:

$$\begin{aligned} VN = &+ 3.598\ AG - 3.243\ ST + 4.250\ TG - 3.568\ LD - 0.265\ DN + 0.497\ HN \\ &[-4.387]^{**}\quad [3.804]^{**}\quad [-5.751]^{**}\quad [6.557]^{**}\quad [0.727]^{ns}\quad [-1.084]^{ns} \\ &R^2 = 0.9532 \end{aligned} \tag{1}$$

$$\begin{aligned} HCM = &-1.879\ AG + 0.069\ ST + 1.266\ TG + 0.420\ LD + 0.324\ DN + 0.734\ HN \\ &[5.425]^{**}\quad [0.193]^{ns}\quad [-4.057]^{**}\quad [-1.829]^{*}\quad [-2.099]^{**}\quad [-3.787]^{*} \\ &R^2 = 0.9165 \end{aligned} \tag{2}$$

$$\begin{aligned} CT = &- 0.766\ AG + 1.136\ ST + 0.231\ TG + 0.306\ LD + 0.115\ DN - 0.055\ HN \\ &[6.501]^{**}\quad [-9.276]^{***}\quad [-2.175]^{*}\quad [-3.911]^{**}\quad [-2.187]^{*}\quad [0.846]^{ns} \\ &R^2 = 0.9327 \end{aligned} \tag{3}$$

Note: All figures in parenthesis […] are t-values: *** = significant at 1%, ** = significant at 5%, * = significant at 10%, ns = not significant.

The significant coefficients in the co-integrating equations (1) and (2) above indicate that in the long-run most markets in the Mekong River Delta are highly co-integrated with HCM City and especially with the export price of Vietnam. Rice is a major product for export and the Mekong River Delta is the rice basket in the country. Therefore, the price formation process in this region highly depends on the world rice markets. HCM City is the major urban centre in the South of Vietnam and, therefore, is expected to be integrated with the major grain baskets in the South. Two market places, located in the Centre and the North of Vietnam: Danang and Hanoi, are not significantly present in the co-integrating equation (1). This result may be explained by the fact that these markets are no major surplus areas but urban consumer centres. As expected, these markets are related to the price levels observed in

HCM City. However, the relationship is somewhat weak. This might be due to the long distance (transport costs). Furthermore, co-integrating equation (3) shows that all markets in the Mekong River Delta are highly co-integrated in the long run.[5] This result clearly indicates that the rice market system in the South is strongly integrated.

Step 4: Testing short-run integration with a Vector Error Correction Model

When long-run integration is observed, it can be incorporated in the model, by specifying a Vector Error Correction Model (VECM). This VECM can then be used to estimate the dynamics in the short-run. Using the same price series as in step 3 we obtain the results presented in Appendix 3. The short-run dynamics are presented in Table 4. The numbers presented are the coefficients of the co-integrating relations in the regression for the price changes.

Table 4 : Estimate the dynamics in the short-run by using VECM

Er. Correction	D(VN)	D(HCM)	D(CT)	D(AG)	D(ST)	D(TG)	D(LD)	D(DN)	D(HN)
CointEq1	-0.019593	-0.029363	-0.028046	0.012855	0.008991	0.065214	-0.055013	-0.013811	-0.018373
	(0.01899)	(0.01610)	(0.01378)	(0.01723)	(0.01497)	(0.01483)	(0.01840)	(0.01530)	(0.01593)
	[-1.03156]	[-1.82387]	[-2.03566]	[0.74624]	[0.60044]	[4.39619]	[-2.99045]	[-0.90256]	[-1.15367]
CointEq2	0.015752	-0.004872	0.076943	-0.165163	-0.078770	0.036218	-0.018738	0.046136	0.118912
	(0.04449)	(0.03771)	(0.03227)	(0.04035)	(0.03507)	(0.03474)	(0.04309)	(0.03584)	(0.03730)
	[0.35409]	[-0.12921]	[2.38446]	[-4.09353]	[-2.24607]	[1.04241]	[-0.43488]	[1.28725]	[3.18788]
CointEq3	-0.154306	-0.000200	-0.266788	0.101853	0.415107	0.317987	0.181434	0.048756	-0.067354
	(0.13002)	(0.11021)	(0.09431)	(0.11793)	(0.10250)	(0.10155)	(0.12593)	(0.10475)	(0.10902)
	[-1.18677]	[-0.00182]	[-2.82872]	[0.86370]	[4.04976]	[3.13133]	[1.44071]	[0.46543]	[-0.61780]

Note: All figures in parenthesis […] are t-values

Table 4 shows that the four major rice production markets in the Mekong River Delta: Cantho (CT), Angiang (AG), Soctrang (ST) and Tiengiang (TG) strongly react on the long-run co-integrating equations. The partial short-run adjustment of price changes at those market places reacts significantly on the deviation from the long-run equilibrium. Tiengiang is the strongest follower of the co-integrating equation (1) and Angiang is the strongest follower of the co-integrating equation (2), as measured by the coefficients: 0.065214 and 0.165163 for Tiengiang and Angiang respectively. In the co-integrating equation (3) Tiengiang and Soctrang have a stronger reaction than the others (0.415107 and 0.317987). Finally, the Cantho rice market is a special market, as it reacts on all of the three co-integrating equations.

In conclusion, the price dynamics in the short-run show that the markets in the South are strongly integrated. This indicates that arbitrage is operational and efficient in the Mekong River Delta.

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[5] Except Hanoi - the consumer market located far in the North, due to the long distance, therefore, it is not significant in co-integrating equation 3.

5. Rice price integration between Vietnam and Thailand

After the market reform, Vietnam has become the second largest rice exporter in the world market after Thailand. Every year, more than 50 percent of the Vietnamese rice is exported. The fluctuation of the world price highly effects the price changes in the domestic market. In this context, information about the relation between the Vietnam price and the world market price is important for the analysis of the functioning of domestic rice market. In this section, the export price of Thailand rice in the world market was used to test for price integration with Vietnam.

Weekly data on the rice price in Thailand, obtained from the USDA, and the price in Vietnam, obtained from Vitranet, will be used for this analysis. The Johansen procedure is applied for analyzing rice price integration between Vietnam and Thailand.

First of all, a unit root test (ADF test) was carried out and the lag length (using VAR analysis) was determined. The price series for the two markets Vietnam and Thailand are integrated of order 1, and the result of a VAR analysis on the first differences of the price series shows that the smallest value of AIC and SC is achieved for lag length 1 (Appendix 4).

The result of the Johansen co-integration test (EVIEWS) shows that rank of π equals 1 (for both the λ_{trace} and λ_{max} tests at 95% significant level).[6]

Testing for long-term price integration between Vietnam and Thailand (See Appendix 4) shows that if we normalize with respect to the export price of Vietnam, we obtain a very high significant co-integrating equation:

$$\text{Vietnam} = \underset{[-19.883]}{1.009534}\ \text{Thailand} - \underset{[1.195]}{12.57837}$$

$$R^2 = 0.9124$$

The above co-integrating equation implies that in the long run, the Vietnamese rice market is highly co-integrated with Thailand and the coefficient of correlation is not significantly different from 1. An increase (or decrease) of export prices in Thailand will be transferred directly to the Vietnamese export prices (See also Figure 1). The constant of this co-integrating equation, however, is not significant. It indicates that in the long run the export price of Vietnam may be equal to the export price of Thailand. We conclude that the suitable model for analysing the process of short-run price integration should be restricted by the condition that the export price of Vietnam follows the price pattern in Thailand. Additionally, as seen in Figure 1, the prices in both Vietnam and Thailand have two extreme fluctuations during March and June of 1999 (due to the shock on rice demand in Indonesia and Iraq). Therefore we include two dummy variables (D1 and D2) in this model. Using a Vector Error Correction Model (VECM), the speed of adjustment in the short-run between the Vietnamese and the Thai price was estimated.

The result in Table 5 indicates that if we put the restriction that the Vietnamese price follows the price pattern in Thailand, the constant in the co-integrating equation of our model is highly significant. Moreover, both dummy variables D1 and D2 related to the extreme price fluctuations in 1999 are also significant. The co-integrating equation now becomes:

[6] See Appendix 4

$$\text{Vietnam} = \text{Thailand} - 9.885348$$
$$[-4.785]$$
$$R^2 = 0.9362$$

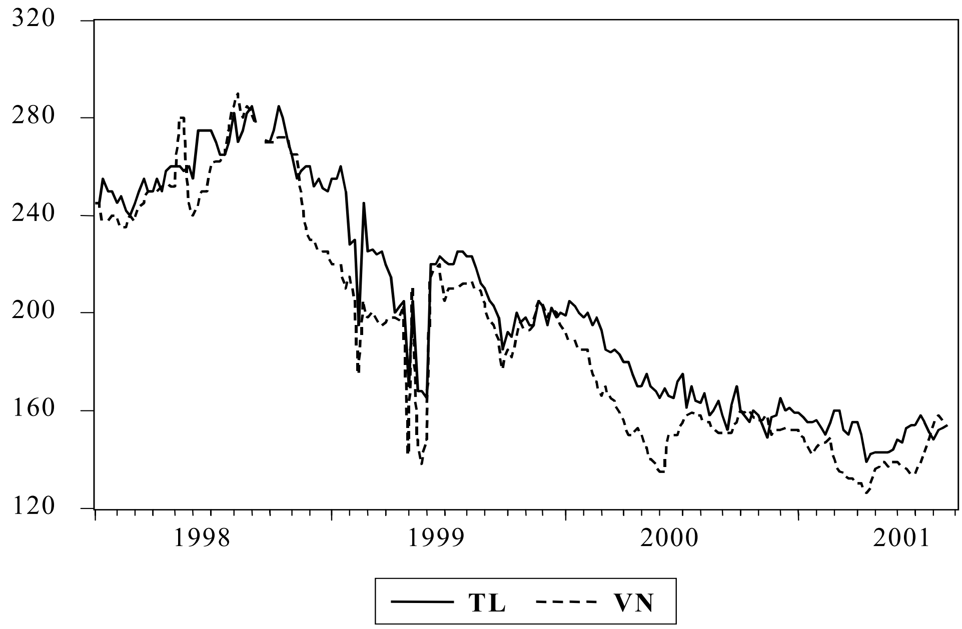
The result of the Vector Error Correction Model (VECM) at the right hand side of Table 5 shows that price changes in Thailand depend on the long-run co-integrating equation with Vietnam. In more detail, as shown in the table the present price changes in Thailand are strongly correlated with the price changes in Vietnam in the previous period.

Table 5 : Estimate of the dynamics in the short-run between Vietnam and Thai's price (Co-integration restrictions)

Co-integrating Equation	Co-integration Equation 1	Error Correction	D(VN)	D(TL)
VN(-1)	1.000000	CointEq1	-0.077991	0.161120
			(0.05675)	(0.04240)
TL(-1)	-1.000000		[-1.37418]	[3.79967]
C	9.885348	D(VN(-1))	-0.282964	-0.192868
	(2.06583)		(0.07749)	(0.05789)
	[4.78516]		[-3.65172]	[-3.33136]
		D(TL(-1))	0.017457	-0.106825
	R^2= 0.9362		(0.09313)	(0.06958)
			[0.18745]	[-1.53527]
		D(D1)	-27.86632	-38.07995
			(5.93343)	(4.43313)
			[-4.69649]	[-8.58986]
		D(D2)	-64.02464	-46.32708
			(5.83384)	(4.35872)
			[-10.9747]	[-10.6286]

Note: All figures in parenthesis […] are t-values

Figure 1: Export rice prices of Vietnam and Thailand 1998 - 2001



Note: Prices of 25 percent broken rice
Source: USDA and Vitranet

6. Conclusions

This study mainly focuses on analyzing the efficiency of the functioning of the rice market that can measure by assessing market integration.

The results of market integration analysis showed that:

(1) All major market places in the Mekong River Delta are highly integrated.

(2) Rice prices follow the export price and the prices in HCM City.

(3) Due to the long distance, markets in the North are not strongly integrated with the Mekong Delta markets.

(4) At the international level, we found that the export price of Vietnamese rice, which is controlled by the government, is highly correlated with the world price (Thailand price).

(5) The price formation process in both domestic and export rice markets cohere. This shows that the floor price policy of the government follows the price pattern in the world market.

Finally we conclude that the data support the view that the domestic rice market in Vietnam is liberalized and highly competitive. However, rice trade between the North and the South is determined by administrative prices making private trade between these regions unprofitable. We also observed that private traders obtained only a very small percentage of the total export quota. This crucial segment in the rice market is still controlled by state owned food companies. Therefore, we conclude that the privatization process in this market still faces some major challenges.

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APPENDICES

Appendix 1 *Vector Autoregression Estimates*

	DAG	DCT	DDN	DHCM	DHN	DLD	DST	DTG	DVN
DAG(-1)	-0.285287	0.078106	-0.039787	0.070749	-0.092429	0.057910	0.046693	-0.051553	0.070922
	(0.07713)	(0.06015)	(0.06610)	(0.06935)	(0.07019)	(0.08333)	(0.06726)	(0.06780)	(0.08109)
	[-3.69875]	[1.29863]	[-0.60190]	[1.02015]	[-1.31688]	[0.69492]	[0.69423]	[-0.76040]	[0.87466]
DCT(-1)	0.120593	-0.298525	0.139565	0.247117	0.049224	-0.000644	0.053483	0.157961	0.140961
	(0.09907)	(0.07725)	(0.08490)	(0.08908)	(0.09015)	(0.10704)	(0.08639)	(0.08708)	(0.10415)
	[1.21726]	[-3.86428]	[1.64382]	[2.77417]	[0.54601]	[-0.00601]	[0.61908]	[1.81395]	[1.35345]
DDN(-1)	0.031746	0.058827	-0.178542	-0.083241	-0.106308	-0.004285	-0.112908	0.011978	0.124947
	(0.08656)	(0.06750)	(0.07418)	(0.07783)	(0.07877)	(0.09352)	(0.07548)	(0.07609)	(0.09100)
	[0.36675]	[0.87155]	[-2.40680]	[-1.06953]	[-1.34963]	[-0.04582]	[-1.49584]	[0.15743]	[1.37308]
DHCM(-1)	-0.051002	-0.148395	0.109881	-0.173991	0.158599	0.188982	-0.044136	-0.066068	-0.059960
	(0.08431)	(0.06574)	(0.07225)	(0.07581)	(0.07672)	(0.09109)	(0.07352)	(0.07411)	(0.08863)
	[-0.60493]	[-2.25718]	[1.52075]	[-2.29518]	[2.06722]	[2.07469]	[-0.60032]	[-0.89151]	[-0.67649]
DHN(-1)	0.148370	0.046787	0.028519	0.057349	-0.229403	0.159118	0.126215	0.112946	0.030239
	(0.08216)	(0.06407)	(0.07041)	(0.07388)	(0.07477)	(0.08877)	(0.07165)	(0.07222)	(0.08638)
	[1.80579]	[0.73026]	[0.40502]	[0.77628]	[-3.06822]	[1.79248]	[1.76161]	[1.56390]	[0.35008]
DLD(-1)	-0.101030	0.106890	0.129809	-0.046020	0.000944	-0.196173	0.070398	0.138538	0.019008
	(0.07317)	(0.05705)	(0.06270)	(0.06579)	(0.06658)	(0.07905)	(0.06380)	(0.06431)	(0.07692)
	[-1.38085]	[1.87352]	[2.07021]	[-0.69953]	[0.01417]	[-2.48168]	[1.10339]	[2.15417]	[0.24712]
DST(-1)	0.116225	0.127112	0.062272	-0.010497	0.037846	0.143204	-0.158688	0.002670	0.032729
	(0.10318)	(0.08046)	(0.08842)	(0.09277)	(0.09389)	(0.11147)	(0.08997)	(0.09069)	(0.10847)
	[1.12646]	[1.57989]	[0.70424]	[-0.11315]	[0.40309]	[1.28464]	[-1.76373]	[0.02944]	[0.30174]
DTG(-1)	0.007814	0.037677	-0.003937	-0.088467	0.049917	-0.091992	0.029133	-0.267948	-0.081426
	(0.08365)	(0.06523)	(0.07169)	(0.07521)	(0.07612)	(0.09038)	(0.07294)	(0.07353)	(0.08794)
	[0.09342]	[0.57761]	[-0.05492]	[-1.17621]	[0.65576]	[-1.01787]	[0.39939]	[-3.64415]	[-0.92593]
DVN(-1)	0.064492	0.087290	0.085996	0.169892	0.058097	0.145715	0.023627	0.107221	-0.304827
	(0.06700)	(0.05225)	(0.05742)	(0.06024)	(0.06097)	(0.07239)	(0.05843)	(0.05889)	(0.07044)
	[0.96254]	[1.67071]	[1.49764]	[2.82003]	[0.95286]	[2.01292]	[0.40439]	[1.82056]	[-4.32761]

Appendix 1 *(Continued)*

	DAG	DCT	DDN	DHCM	DHN	DLD	DST	DTG	DVN
R-squared	0.129703	0.169797	0.098184	0.125352	0.092792	0.091183	0.059097	0.127137	0.131106
Adj. R-squared	0.090367	0.132274	0.057424	0.085820	0.051788	0.050107	0.016570	0.087685	0.091834
Sum sq. resids	3720154.	2262088.	2732319.	3007630.	3080583.	4342499.	2828869.	2874320.	4111459.
S.E. equation	144.9752	113.0494	124.2450	130.3544	131.9258	156.6330	126.4212	127.4327	152.4093
F-statistic	3.297348	4.525103	2.408841	3.170885	2.263005	2.219841	1.389640	3.222613	3.338397
Log likelihood	-1184.951	-1138.685	-1156.250	-1165.178	-1167.407	-1199.336	-1159.479	-1160.962	-1194.252
Akaike AIC	12.83818	12.34070	12.52957	12.62557	12.64953	12.99287	12.56429	12.58023	12.93819
Schwarz SC	12.99426	12.49679	12.68565	12.78165	12.80562	13.14895	12.72038	12.73632	13.09428
Mean dependent	0.806452	-2.150538	-0.107527	-0.376344	-0.376344	-2.849462	-0.537634	-0.806452	-4.796774
S.D. dependent	152.0060	121.3603	127.9738	136.3357	135.4806	160.7111	127.4818	133.4162	159.9295
Determinant Residual Covariance		7.33E+37							
Log Likelihood (d.f. adjusted)		-10483.75							
Akaike Information Criteria		113.5995							
Schwarz Criteria		115.0043							

Note: (1) Included observations: 186. Excluded observations: 3 after adjusting endpoints.
(2) Standard errors in ( ) & t-statistics in [ ]

Appendix 2 *Johansen Co-integration Test*
Normalized co-integrating coefficients (standard error in parentheses)

Co-integating equation	VN	HCM	CT	AG	ST	TG	LD	DN	HN
(1) R^2= 0.9532	1.000000	0.000000	0.000000	-3.598265	3.243148	-4.250613	3.568764	0.265870	-0.497459
				(0.81548)	(0.84762)	(0.73482)	(0.54112)	(0.36356)	(0.45613)
(2) R^2= 0.9165	0.000000	1.000000	0.000000	1.879818	-0.069662	-1.266777	-0.420700	-0.324372	-0.734023
				(0.34451)	(0.35809)	(0.31044)	(0.22861)	(0.15359)	(0.19270)
(3) R^2= 0.9327	0.000000	0.000000	1.000000	0.766660	-1.136914	-0.231148	-0.306059	-0.115016	0.055629
				(0.11724)	(0.12186)	(0.10565)	(0.07780)	(0.05227)	(0.06558)

Adjustment coefficients (std.err. in parentheses)

D(VN)	-0.019593	0.015752	-0.154306
	(0.01889)	(0.04423)	(0.12928)
D(HCM)	-0.029363	-0.004872	-0.000200
	(0.01601)	(0.03749)	(0.10958)
D(CT)	-0.028046	0.076943	-0.266788
	(0.01370)	(0.03208)	(0.09378)
D(AG)	0.012855	-0.165163	0.101853
	(0.01713)	(0.04012)	(0.11725)
D(ST)	0.008991	-0.078770	0.415107
	(0.01489)	(0.03487)	(0.10192)
D(TG)	0.065214	0.036218	0.317987
	(0.01475)	(0.03455)	(0.10097)
D(LD)	-0.055013	-0.018738	0.181434
	(0.01829)	(0.04284)	(0.12522)
D(DN)	-0.013811	0.046136	0.048756
	(0.01521)	(0.03564)	(0.10416)
D(HN)	-0.018373	0.118912	-0.067354
	(0.01584)	(0.03709)	(0.10840)

Appendix 3 *Vector Error Correction Estimates*

Error Correction:	D(VN)	D(HCM)	D(CT)	D(AG)	D(ST)	D(TG)	D(LD)	D(DN)	D(HN)
CointEq1	-0.019593	-0.029363	-0.028046	0.012855	0.008991	0.065214	-0.055013	-0.013811	-0.018373
	(0.01899)	(0.01610)	(0.01378)	(0.01723)	(0.01497)	(0.01483)	(0.01840)	(0.01530)	(0.01593)
	[-1.03156]	[-1.82387]	[-2.03566]	[0.74624]	[0.60044]	[4.39619]	[-2.99045]	[-0.90256]	[-1.15367]
CointEq2	0.015752	-0.004872	0.076943	-0.165163	-0.078770	0.036218	-0.018738	0.046136	0.118912
	(0.04449)	(0.03771)	(0.03227)	(0.04035)	(0.03507)	(0.03474)	(0.04309)	(0.03584)	(0.03730)
	[0.35409]	[-0.12921]	[2.38446]	[-4.09353]	[-2.24607]	[1.04241]	[-0.43488]	[1.28725]	[3.18788]
CointEq3	-0.154306	-0.000200	-0.266788	0.101853	0.415107	0.317987	0.181434	0.048756	-0.067354
	(0.13002)	(0.11021)	(0.09431)	(0.11793)	(0.10250)	(0.10155)	(0.12593)	(0.10475)	(0.10902)
	[-1.18677]	[-0.00182]	[-2.82872]	[0.86370]	[4.04976]	[3.13133]	[1.44071]	[0.46543]	[-0.61780]
D(VN(-1))	-0.294609	0.188498	0.098271	0.067294	0.025631	0.066463	0.182379	0.092102	0.061805
	(0.07159)	(0.06068)	(0.05193)	(0.06493)	(0.05644)	(0.05591)	(0.06934)	(0.05768)	(0.06003)
	[-4.11520]	[3.10634]	[1.89240]	[1.03640]	[0.45414]	[1.18867]	[2.63023]	[1.59685]	[1.02960]
D(HCM(-1))	-0.063935	-0.185644	-0.188276	0.063750	-0.029706	-0.094788	0.153390	0.063733	0.070579
	(0.09360)	(0.07934)	(0.06789)	(0.08489)	(0.07379)	(0.07310)	(0.09066)	(0.07541)	(0.07848)
	[-0.68308]	[-2.33998]	[-2.77312]	[0.75096]	[-0.40259]	[-1.29665]	[1.69201]	[0.84518]	[0.89930]
D(CT(-1))	0.217139	0.248675	-0.170166	0.080025	-0.147447	-0.004309	-0.087135	0.113074	0.075830
	(0.12229)	(0.10366)	(0.08871)	(0.11091)	(0.09641)	(0.09551)	(0.11844)	(0.09852)	(0.10254)
	[1.77561]	[2.39905]	[-1.91832]	[0.72151]	[-1.52944]	[-0.04511]	[-0.73566]	[1.14768]	[0.73952]
D(AG(-1))	0.076027	0.009031	0.056619	-0.153626	-0.033593	-0.066194	-0.123489	-0.131050	-0.210171
	(0.09410)	(0.07976)	(0.06826)	(0.08535)	(0.07418)	(0.07349)	(0.09114)	(0.07581)	(0.07890)
	[0.80793]	[0.11322]	[0.82949]	[-1.80003]	[-0.45283]	[-0.90067]	[-1.35491]	[-1.72860]	[-2.66368]
D(ST(-1))	-0.030440	0.024451	0.010702	0.158753	0.063586	0.102881	0.310611	0.105853	0.021456
	(0.12586)	(0.10668)	(0.09129)	(0.11415)	(0.09922)	(0.09830)	(0.12190)	(0.10140)	(0.10553)
	[-0.24187]	[0.22920]	[0.11723]	[1.39078]	[0.64088]	[1.04665]	[2.54813]	[1.04396]	[0.20332]
D(TG(-1))	-0.123729	-0.143310	0.010557	-0.075967	0.040313	-0.087862	-0.178784	0.011327	0.095057
	(0.09914)	(0.08404)	(0.07192)	(0.08992)	(0.07816)	(0.07743)	(0.09603)	(0.07988)	(0.08313)
	[-1.24798]	[-1.70534]	[0.14680]	[-0.84483]	[0.51578]	[-1.13469]	[-1.86183]	[0.14181]	[1.14346]
D(LD(-1))	0.034156	0.006736	0.126023	-0.121752	0.106187	0.067203	-0.072786	0.164799	0.033189
	(0.08228)	(0.06974)	(0.05968)	(0.07463)	(0.06487)	(0.06426)	(0.07969)	(0.06629)	(0.06899)
	[0.41511]	[0.09658]	[2.11148]	[-1.63147]	[1.63701]	[1.04573]	[-0.91331]	[2.48598]	[0.48105]
D(DN(-1))	0.120899	-0.071055	0.050150	0.032089	-0.084295	0.010983	0.033105	-0.168120	-0.102259
	(0.09176)	(0.07778)	(0.06656)	(0.08322)	(0.07234)	(0.07166)	(0.08887)	(0.07392)	(0.07694)
	[1.31760]	[-0.91359]	[0.75348]	[0.38559]	[-1.16533]	[0.15326]	[0.37250]	[-2.27420]	[-1.32911]
D(HN(-1))	0.035225	0.036667	0.072440	0.103995	0.074258	0.137298	0.101610	0.027274	-0.204015
	(0.08866)	(0.07515)	(0.06431)	(0.08042)	(0.06990)	(0.06925)	(0.08588)	(0.07143)	(0.07434)
	[0.39728]	[0.48790]	[1.12634]	[1.29322]	[1.06238]	[1.98267]	[1.18321]	[0.38182]	[-2.74419]

Appendix 3 *(Continued)*

	D(VN)	D(HCM)	D(CT)	D(AG)	D(ST)	D(TG)	D(LD)	D(DN)	D(HN)
R-squared	0.139313	0.149082	0.213558	0.216272	0.158148	0.245581	0.200420	0.127508	0.156764
Adj. R-squared	0.084902	0.095289	0.163840	0.166726	0.104928	0.197888	0.149872	0.072350	0.103456
Sum sq. resids	4072623.	2926028.	2142851.	3350108.	2531067.	2484287.	3820543.	2643475.	2863354.
S.E. equation	152.9898	129.6775	110.9740	138.7570	120.6083	119.4885	148.1794	123.2574	128.2812
F-statistic	2.560373	2.771373	4.295410	4.365069	2.971562	5.149180	3.964942	2.311698	2.940721
Log likelihood	-1193.369	-1162.620	-1133.649	-1175.207	-1149.134	-1147.399	-1187.427	-1153.175	-1160.606
Akaike AIC	12.96096	12.63032	12.31881	12.76567	12.48531	12.46666	12.89707	12.52877	12.60867
Schwarz SC	13.16907	12.83843	12.52692	12.97378	12.69343	12.67477	13.10518	12.73688	12.81678
Mean dependent	-4.796774	-0.376344	-2.150538	0.806452	-0.537634	-0.806452	-2.849462	-0.107527	-0.376344
S.D. dependent	159.9295	136.3357	121.3603	152.0060	127.4818	133.4162	160.7111	127.9738	135.4806
Determinant Residual Covariance		3.60E+37							
Log Likelihood		-10361.80							
Log Likelihood (d.f. adjusted)		-10417.62							
Akaike Information Criteria		113.4690							
Schwarz Criteria		115.8103							

Note: (1) Included observations: 186. Excluded observations: 3 after adjusting endpoints.
(2) Standard errors in ( ) & t-statistics in [ ]

Appendix 4 *Results of market integration analysis: the case of Vietnam and Thailand*

<u>Vector Auto-regression Estimates</u>

	DVN	DTL
DVN(-1)	-0.265231	-0.056537
	(0.09560)	(0.07608)
	[-2.77439]	[-0.74310]
DTL(-1)	-0.080894	-0.328602
	(0.11720)	(0.09328)
	[-0.69020]	[-3.52292]
C	-0.583157	-0.607139
	(0.80530)	(0.64089)
	[-0.72415]	[-0.94733]
R-squared	0.098368	0.143300
Adj. R-squared	0.088514	0.133937
Sum sq. resids	22028.54	13952.18
S.E. equation	10.97153	8.731634
F-statistic	9.982611	15.30520
Log likelihood	-707.9369	-665.4635
Akaike AIC	7.644483	7.187780
Schwarz SC	7.696511	7.239808
Mean dependent	-0.440860	-0.446237
S.D. dependent	11.49191	9.382549
Determinant Residual Covariance	5226.224	
Log Likelihood (d.f. adjusted)	-1324.059	
Akaike Information Criteria	14.30171	
Schwarz Criteria	14.40577	

Note: Standard errors in ( ) & t-statistics in [ ]

Appendix 4 *(Continued)*

Johansen Co-integration Test *(one Co-integrating equation)*

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.108413	22.37014	15.41	20.04
At most 1	0.005502	1.026243	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 1 co-integrating equation(s) at the 5% level
Trace test indicates no co-integration at the 1% level

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.113068	22.31752	15.67	20.20
At most 1	0.008598	1.606144	9.24	12.97

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigen value test indicates 1 co-integrating equation(s) at both 5% and 1% levels

Unrestricted Co-integrating Coefficients (normalized by b'*S11*b=I):

VN	TL	C
0.094750	-0.095654	1.191803
0.003015	0.012813	-2.445058

Unrestricted Adjustment Coefficients (alpha):

D(VN)	-1.506037	-0.921265
D(TL)	1.216969	-0.731774

1 Co-integrating Equation(s): Log likelihood -1310.341

Normalized co-integrating coefficients (standard error in parentheses)

VN	TL	C	
1.000000	-1.009534	12.57837	$R^2 = 0.9124$
	(0.05077)	(10.5251)	

Adjustment coefficients (standard error in parentheses)

D(VN)	-0.142697
	(0.07560)
D(TL)	0.115308
	(0.06021)