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Testing for Food market integration: A study of the Vietnamese paddy market

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Abstract

With its increasing integration into the world economy, agricultural exports and rural incomes in Vietnam have increased substantially in recent years. At the sub–national level, however, there are concerns that not all regions and categories of agricultural producers have and will benefit from the ongoing liberalization of agricultural markets.

Vietnam's elongated geography and lack of spatial market integration pose special problems in this regard. Accordingly, this study aims to answer three interrelated questions: (a) whether there is spatial integration between paddy markets in the North and South of Vietnam; (b) whether there is spatial integration in paddy markets within the North and within the South; and, (c) if within-region integration is stronger and faster than between-region integration.

The empirical model we develop to answer these questions, uses estimates of transfer costs to generalize the well known model of spatial market integration due to Ravallion to allow for the possibility of threshold effects. A sequential testing strategy is developed which progressively tests for market segmentation, the number of thresholds, long-run market integration, common dynamics/informational efficiency, and (a strict version of) the 'Law' of One Price within an error-correction framework.

When the unrestricted version of this model is estimated using monthly paddy prices for eight markets between 1993 and 2006, we find weak evidence of market integration between paddy markets in the North and South of Vietnam with an absence of threshold effects. However, there is evidence of both threshold effects and stronger forms of spatial market integration for paddy markets within the North and within the

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South, with at least 60% percent of price changes being transmitted between markets within one month whenever price spreads exceeds their upper or lower thresholds. The extent and speed of price transmission within regional paddy markets is generally faster in the South than the North of Vietnam. However, the instantaneous version of the 'Law' of One Price, which requires full price adjustment to occur within a month, only holds for a few regimes and market pairs.

Three main policy implications flow from these results. First, since there is limited evidence of integration between paddy markets in the North and South of Vietnam, national level policies cannot be relied upon to stabilize or support paddy prices. Second, since there is evidence of spatial market integration within the Red River and Mekong River deltas, paddy markets within these regions can be relied upon to transmit price signals between deficit and surplus areas relatively well. Third, since the speed and extent of price transmission is relatively rapid within the North and within the South of Vietnam, the private sector trade can be relied upon to transfer rice and paddy between markets in an efficient manner. Problems might, however, emerge if large demand-supply imbalances were to emerge between the North and South, as transfer costs would prevent private sector trade taking place. In these circumstances, the public sector might need to intervene, in a consistent and market friendly way, to ensure adequate food supplies in the short-term.

Keywords: market integration, paddy market, error-correction, spatial integration

1 Introduction

With its increasing integration into the world economy, Vietnam's agricultural exports have grown substantially in recent years. From being a net importer of rice in the late 1980s, by the late 1990s Vietnam had become one of the largest rice exporting countries. Paddy production has grown from about 23 million metric tons in 1993 to around 36 million metric tons in 2005, with 70 percent of total paddy output coming from the Red River and Mekong River deltas.

At the sub–national level, there are concerns that not all regions and categories of agricultural producers have and will benefit from the liberalization of Vietnam's agricultural markets. There are two distinct aspects to these concerns. First, if domestic markets are not spatially integrated, not all regions will benefit from market and trade liberalization to the same extent. The elongated geography of Vietnam poses special problems in this regard. Second, even if domestic markets are integrated in the long term, lack of integration in the short-term may mean that price changes are not transmitted between consumption centres and production areas quickly enough. If this is the case, agricultural market liberalization may disproportionately benefit traders and agricultural processors rather than agricultural producers and consumers.

Accordingly, this study aims to answer three interrelated questions. The first question is whether there is spatial integration between paddy markets in the North and South of Vietnam. The elongated geography of Vietnam results in high transfer costs for food market transactions between the northern and the southern regions. This makes it interesting to look into the degree of integration in the paddy markets, as trade is in all likelihood not the determining factor for market integration between the North and the South of Vietnam.

The second question we seek to answer is whether there is spatial integration in paddy markets within the North and within the South, specifically in the Red River and Mekong River deltas. We focus on paddy prices in the Red River and Mekong deltas for this analysis, both because they produce over two-thirds of national paddy output and because the price data for these regions is fairly comprehensive and complete.

Finally, a natural third question to ask is if within-region integration is stronger and faster than between-region integration.

Our analysis, which uses threshold error correction models to sequentially test for different forms of market integration using monthly paddy prices for

eight provinces in Vietnam, indicates a weak integration of the paddy markets between the North and the South of Vietnam. However, within the northern and southern regions, there is evidence of stronger market integration, with 50 to 85 percent of price changes being transmitted between markets within one month whenever inter-market price spreads are large enough to induce profitable trade flows between provinces.

This chapter is structured as follows. In Section 2 we provide an overall description of the paddy production in Vietnam from the beginning of the 1990s to 2005. Section 3 discusses the importance of thresholds when analyzing spatial market integration in the presence of transfer costs and describes our modeling and testing strategy. In Section 4 we describe the paddy price data used and how we have estimated transfer costs. Descriptive statistics and (linear) tests of stationarity and cointegration are also presented in this section. In Section 5, we use the paddy price series to test for various forms of market integration between the North and South of Vietnam as well as within these regions. Finally, Section 6 offers some concluding remarks and policy recommendations.

2 Paddy Production, Distribution and Marketing

Rice is the main staple in the Vietnamese diet. In the 1990s, household expenditure on rice was about 45 percent of total food expenditure in the rural areas and about 25 percent in the urban areas (Benjamin and Brandt, 2004). Rice policy issues ranging from measures to assist in the growing of paddy to the regulation of exports have considerable importance for agricultural researchers and policy makers. This section highlights some salient features of the Vietnamese paddy market.

2.1 Natural conditions for paddy production

About two thirds of Vietnamese farm households grow paddy to serve the high domestic demand for rice, exclusive of exporting requirement. Roughly 53 percent of Vietnam's agricultural land area, which is approximately 4 million hectares, is devoted to the growing of paddy (Minot and Golleti, 1999; FAOSTAT, 2006). Benjamin and Brandt (2004) summarize the state of Vietnamese paddy production as: "Rice production in Viet Nam is characterized by small irrigated farms, multiple cropping, labor-intensive practices, and growing use of inorganic fertilizer, though there are substantial regional differences". The planted area of paddy accounts for about 88 percent of the area planted of cereals in 2005 (Table 1). Although the area of paddy has been rising during 1993-2005, its share of total planted area of cereal has been declining in this period as a result of the higher growth rate of planted area of cereal compare with that of paddy.

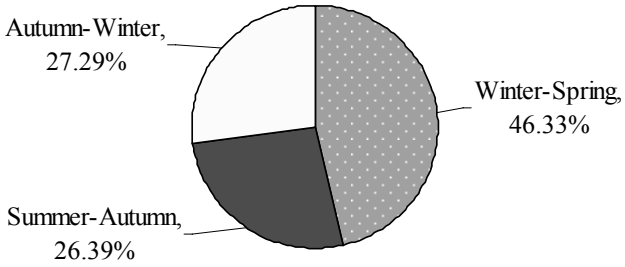
Table 1: Planted land of paddy (thousand hectares)

Year	Agricultural land	Arable land	Planted area of cereal	Planted area of paddy	(4) as percentage of (3)
	(1)	(2)	(3)	(4)	(5)
1993	7087	5516	7058	6559	92.93
1994	7140	5464	7136	6599	92.47
1995	7079	5403	7324	6766	92.37
1996	7682	5554	7621	7004	91.91
1997	7844	5668	7768	7100	91.39
1998	8055	5763	8016	7363	91.85
1999	8413	6000	8349	7654	91.68
2000	8780	6200	8399	7666	91.28
2001	9483	6649	8225	7493	91.10
2002	9455	6600	8323	7504	90.17
2003	9622	6680	8367	7452	89.07
2004	n.a	n.a	8438	7445	88.24
2005 (prel.)	n.a	n.a	8371	7326	87.52

Source: GS0 (2006).

The seasons for paddy growing vary across regions. In the North, there are generally two paddy crops annually: the Winter-Spring crop (planted in February and harvested in May/June) and the Summer-Autumn crop (July to October/November). In irrigated areas in the South, there are usually three paddy crops per year: the Summer-Autumn crop (April/May to August/September), the Autumn-Winter crop (August to November/December) and the Winter-Spring crop (November/December-February) (Minot and Golleti, 1999; Luu, 2003). In rain fed areas in the South, only a wet-season crop is produced, which is generally planted in July/August and harvested between October and February. By producing three crops staggered across the year, Vietnamese producers can supply paddy to the market more or less continuously throughout the year. Nationally, the Winter-Spring crop accounts for just below one-half of paddy production while the Summer-Autumn and Autumn-Winter crops each account for just over one-quarter (Figure 1 and Table 2).

Figure 1: Paddy production by season in 1995-2005



Source: GSO (2006).
Note: Figures for 2005 are preliminary

Table 2: Paddy production by season, 1995-2005

Year	Total (thousand tons)	Of which (%) Winter-Spring	Summer-Autumn	Autumn-Winter
1993	22836.5	39.57	24.67	35.77
1994	23528.2	44.66	24.14	31.20
1995	24963.7	43.01	26.04	30.95
1996	26396.7	46.25	26.06	27.69
1997	27523.9	48.36	24.12	27.52
1998	29145.5	46.52	25.81	27.67
1999	31393.8	44.92	27.90	27.18
2000	32529.5	47.87	26.51	25.62
2001	32108.4	48.19	25.94	25.87
2002	34447.2	48.54	26.67	24.79
2003	34568.8	48.66	27.19	24.14
2004	36148.9	47.24	28.86	23.90
2005 (prel.)	35790.8	48.43	29.10	22.48
Average		46.33	26.39	27.29

Source: GSO (2006).

2.2 The Vietnamese paddy policy

As the main Vietnamese staple food, rice has attracted significant attention from political leaders. Since the introduction of the contract system in 1980 (Directive 100), numerous reforms have been implemented, bringing about wider and deeper liberalization of Vietnam's paddy market, and a rise of around 12 million tons in paddy production from 1995 to 2005 (Figure 2). The main policy changes, which have affected the paddy market since 1980 include:

- The introduction of the *Doi moi* process in late 1986, which marked the beginning of a transition to a more market-oriented economy in Vietnam.
- The liberalization of market was gradually implemented from early 1990s, characterized by:
    - Exemption of duties on imported inputs for producing exported rice and the reduction of tariff on rice export from ten to one percent in 1991.
    - Extension of authority to import fertilizer from central to provincial SOEs with foreign exchange sources of revenues also in 1991. However, the imposition of quotas on, and licensing import of, fertilizer to selected enterprises remained until 2001.
    - Loosening of restrictions and internal barriers to trade in rice between the northern and southern Vietnam was enacted in 1997 (Decree No. 140/TTg).
    - A gradual lifting of the rice export quota, from under one million ton in 1992 to 4.5 million tons in 1998.
    - Abolition of quotas on rice export and fertilizer imports, together with support provided for the rice producers and exporters, in 2001. Since then the free import of fertilizer has supplemented the insufficient amount produced by the domestic fertilizer industry, leading to a decrease in fertilizer price and a rise in the supply of fertilizer. This liberalization of fertilizer import and rice export consequently raised the paddy production and export volume.
- Land reform Resolution 5 (1993) extended land use right, creating incentives in paddy cultivation. The changes included (1) extension of tenure to 20 years for annual crop land and 50 years for perennials; (2) land user's right to exchange, transfer, lease, inherit and mortgage land.

- The declaration of the Water Law in 1999, which established a water allocation system using licenses and permits administered by Ministry of Agriculture and Rural Development (MARD) and the provincial governments. In 2002, the central management of water resource was assigned to the Ministry of Natural Resources and Environment, while the National Water Resources Council together with basin-level committees was set-up to manage and allocate water in the Red River Delta (RRD), Mekong River Delta (MRD) and Dong Nai basins. All these water legislations facilitated the intensification of crops from 1 to 2 or 3 crops per year.

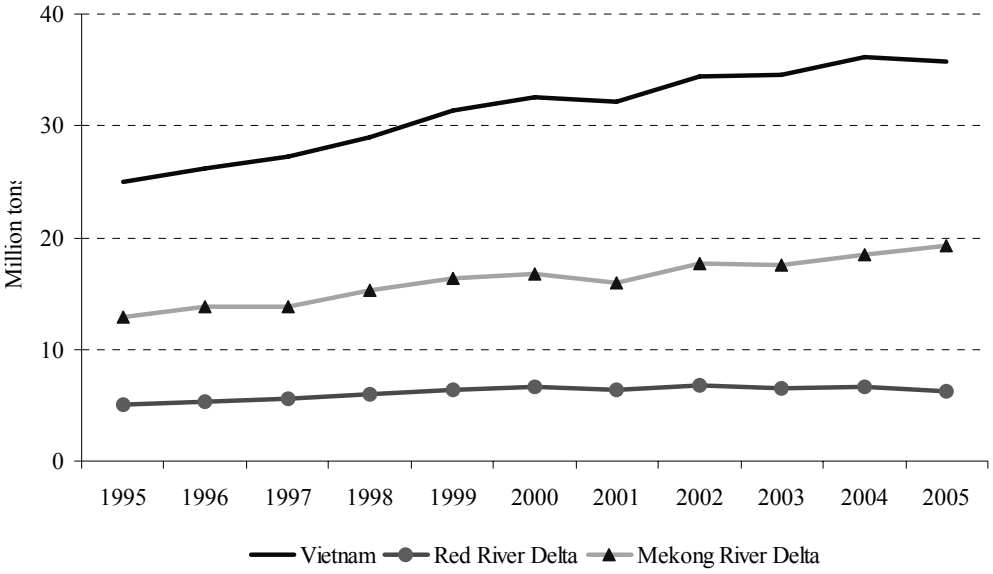
In addition, a gradual improvement of market infrastructure and Vietnam's participation in international organizations has generally improved the trading environment.

2.3 Paddy Production and Consumption

Vietnam's paddy production has been rising continuously during 1995-2005 with an average annual growth rate of 3.7 percent (Figure 3 and Table 3). In addition to the incentives from the rice market liberalization, this growth is attributed to an increase of 2.9 percent in yield of paddy (productivity) and a weak expansion of planted areas devoted to paddy, at the rate of about 0.8 percent per annum.

Vietnam has two main granaries: the MRD in the South and the RRD in the North. These two deltas, which account for 42.5 percent of the population, supply rice to the remaining five regions (the North Uplands, North Central Coast, South Central Coast, Central Highlands, and Southeast). The MRD, the so-called "rice bowl of Vietnam", supply more than a half (52 percent) of national paddy output, followed by the RRD that produces around 20 percent of the total. None of the other five regions accounts for more than 9 percent of national paddy production (Table 3).

Figure 2: Trend of paddy production by region in 1995-2005



Source: **GSO (2006).**

Note: Figures for 2005 are preliminary

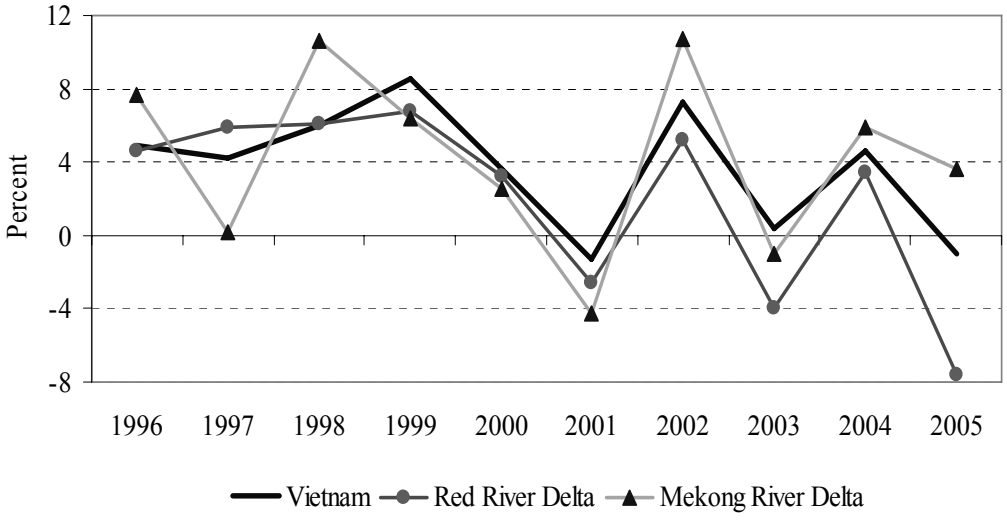
In the RRD, the average annual growth rate of paddy production was 2 percent from 1995 to 2005. That is 2.1 percentage points lower than the growth rate for paddy in the MRD. However, the MRD faces higher variability in production than the RRD (Figure 3). Among the provinces in the RRD, Thai Binh and Nam Dinh rank first and second in paddy production, each accounting for around 3 percent of national output and 15 or 16 percent of RRD's production (Figure 4). They are followed by Ha Tay and Hai Duong with about 14 and 13 percent of RRD's paddy production, respectively. The other seven provinces in the RRD produce less than 8 percent of national paddy production.

Table 3: Paddy production by region, 1995-2005

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average
As proportion of total paddy production (%)												
Vietnam	100	100	100	100	100	100	100	100	100	100	100	
Red River Delta	20.4	20.3	20.7	20.7	20.3	20.2	20.0	19.6	18.8	18.6	17.3	19.7
North East	5.8	6.1	6.3	6.1	6.1	6.3	7.0	6.9	7.2	6.9	7.1	6.5
North West	1.3	1.2	1.3	1.1	1.2	1.2	1.4	1.3	1.4	1.5	1.5	1.3
North Central Coast	8.6	7.8	9.1	8.0	8.4	8.7	9.2	9.2	9.3	9.3	8.8	8.8
South Central Coast	5.7	6.0	5.8	5.4	5.4	5.2	5.3	5.0	5.4	5.2	5.0	5.4
Central Highlands	1.7	1.6	1.8	1.5	1.6	1.8	2.0	1.8	2.2	2.2	2.0	1.8
South East	5.1	4.3	4.3	4.2	5.0	5.2	5.2	4.9	5.0	4.9	4.5	4.8
Mekong River Delta	51.4	52.8	50.8	53.0	51.9	51.3	49.8	51.4	50.7	51.4	53.7	51.7
Growth rate of paddy production (%)												
Vietnam		4.9	4.2	6.0	8.6	3.6	-1.3	7.3	0.4	4.6	-1.0	3.7
Red River Delta		4.6	5.9	6.1	6.8	3.2	-2.5	5.2	-3.9	3.4	-7.6	2.0
North East		8.9	7.8	3.2	8.2	8.0	9.0	5.5	4.2	0.6	1.9	5.7
North West		-4.0	9.4	-3.8	12.0	8.4	9.2	3.8	6.7	12.4	-0.5	5.2
North Central Coast		-4.9	22.6	-7.2	13.7	7.2	5.1	6.4	2.1	4.9	-6.3	4.0
South Central Coast		10.7	0.8	-1.0	8.9	-1.3	1.5	0.2	9.8	0.7	-6.1	2.3
Central Highlands		-0.5	13.6	-10.1	17.4	14.5	10.1	-6.1	23.3	4.5	-8.6	5.2
South East		-12.2	6.0	1.9	31.2	6.2	0.1	-0.1	3.8	2.3	-9.2	2.5
Mekong River Delta		7.7	0.2	10.6	6.4	2.5	-4.2	10.7	-1.0	5.9	3.6	4.1

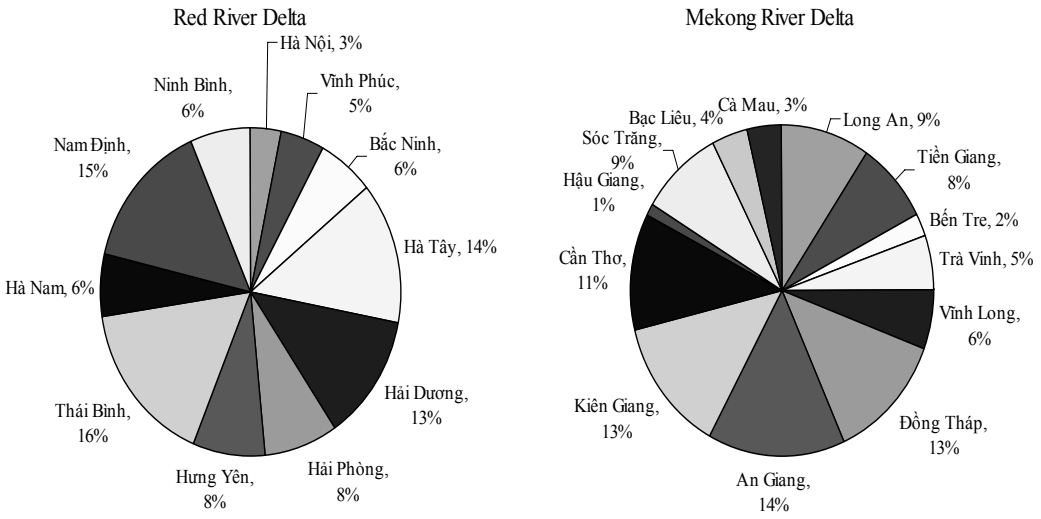
Notes: Figures for 2005 are preliminary.
Source: Computed from GSO (2006).

Figure 3: Growth rate of paddy production by region, 1995-2005



Source: GSO (2006)
Note: Figures for 2005 are preliminary

Figure 4: Paddy production in Red River and Mekong River Deltas, 1995-2005

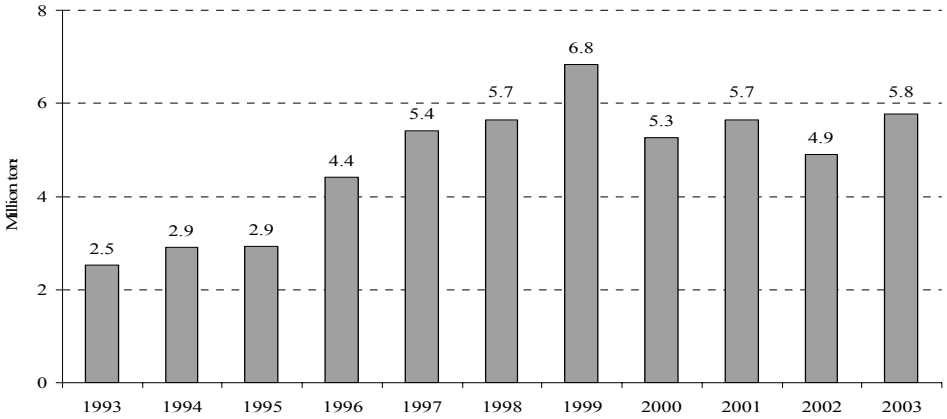


Source: Computed from GSO (2006).
Note: Figures for 2005 are preliminary

The leading paddy growing provinces in the MRD include An Giang, Dong Thap, Kien Giang and Can Tho whose shares of national output are each 6 to 7 percent (accounting for 11 to 14 percent of the MRD's annual paddy production). They are followed by Long An, Soc Trang and Tien Giang, which together account for almost 5 percent of national production. This is equivalent to more than 9 percent of the MRD's annual production (Figure 4).

Besides the domestic demand, Vietnam also supplies rice to the international market. About 83 percent of total annual paddy production is consumed domestically while the other 17 percent is exported. As can be seen from Table 4, the main portion of domestic consumption (about 84 percent) is used for food, with the remaining 16 percent accounted for by waste, seed and feed. Since the mid 1990s, Vietnam has become a major rice exporting country, with the volume of rice exports rising from 2.5 million tons in 1993 to 5.8 million tons in 2003 (Figure 5). In terms of rice export volumes, Vietnam is now the second largest rice exporter in the world after Thailand (Figure 6). However, in terms of value, Vietnam's rice exports rank fourth or fifth in the world market due to the low quality of its rice exports and the limited value-added to paddy (Figure 6).

Figure 5: Vietnam's export of rice in paddy equivalent



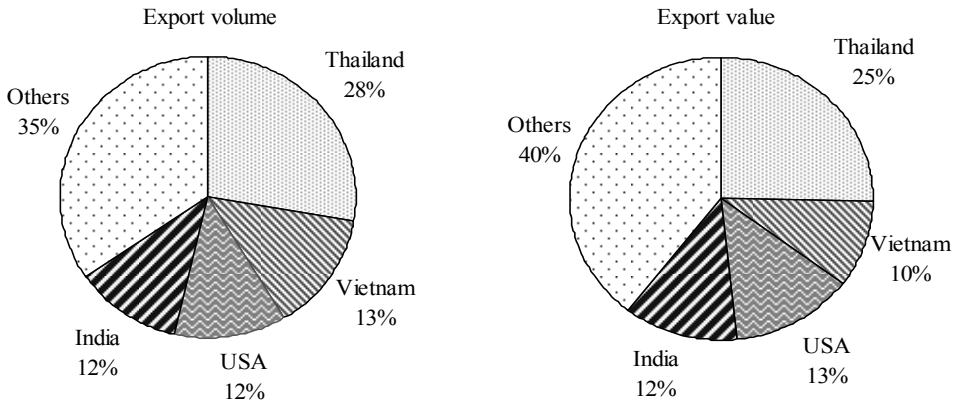
S*ource:* FAOSTAT Data, 2006

Table 4: Distribution of paddy production, 1993-2003

	1993-1995	1996-1998	1999-2001	2002-2003	Average
Paddy (thousand tons)	69127.8	82557.4	89073.8	60064.9	
Production	71328.6	83066.1	96031.7	69016.0	
Imports	17.3	2.0	11.8	64.0	
Stock Change	-2218.1	-510.7	-6969.7	-9015.2	
Provided for:					
Exports	8372.1	15484.1	17749.6	10687.8	
Domestic Supply	60755.7	67073.3	71324.3	49377.1	
In which:					
Feed	1132.6	1270.9	1366.8	1168.2	
Seed	2139.9	2492.0	2881.0	2070.5	
Waste	4865.0	5670.0	6549.6	4714.4	
Food Manufacture	335.9	459.0	608.6	150.7	
Food	51957.9	56802.2	59481.2	40957.4	
Other Uses	324.6	379.2	437.0	315.9	
Paddy (%)	100.0	100.0	100.0	100.0	100.0
Production	103.2	100.6	107.8	114.9	106.6
Imports	0.0	0.0	0.0	0.0	0.0
Stock Change	-3.2	-0.6	-7.8	-15.0	-6.7
Provided for:					
Exports	12.1	18.8	19.9	17.8	17.2
Domestic Supply	87.9	81.2	80.1	82.2	82.9
In which:					
Feed	1.9	1.9	1.9	2.4	2.0
Seed	3.5	3.7	4.0	4.2	3.9
Waste	8.0	8.5	9.2	9.6	8.8
Food Manufacture	0.6	0.7	0.9	0.3	0.6
Food	85.5	84.7	83.4	83.0	84.1
Other Uses	0.5	0.6	0.6	0.6	0.6

Notes: Data for 2004 and 2005 are not available.
Source: Computed from FAOSTAT Data, 2006.

Figure 6: Average shares of rice export volume and values in 1993-2004

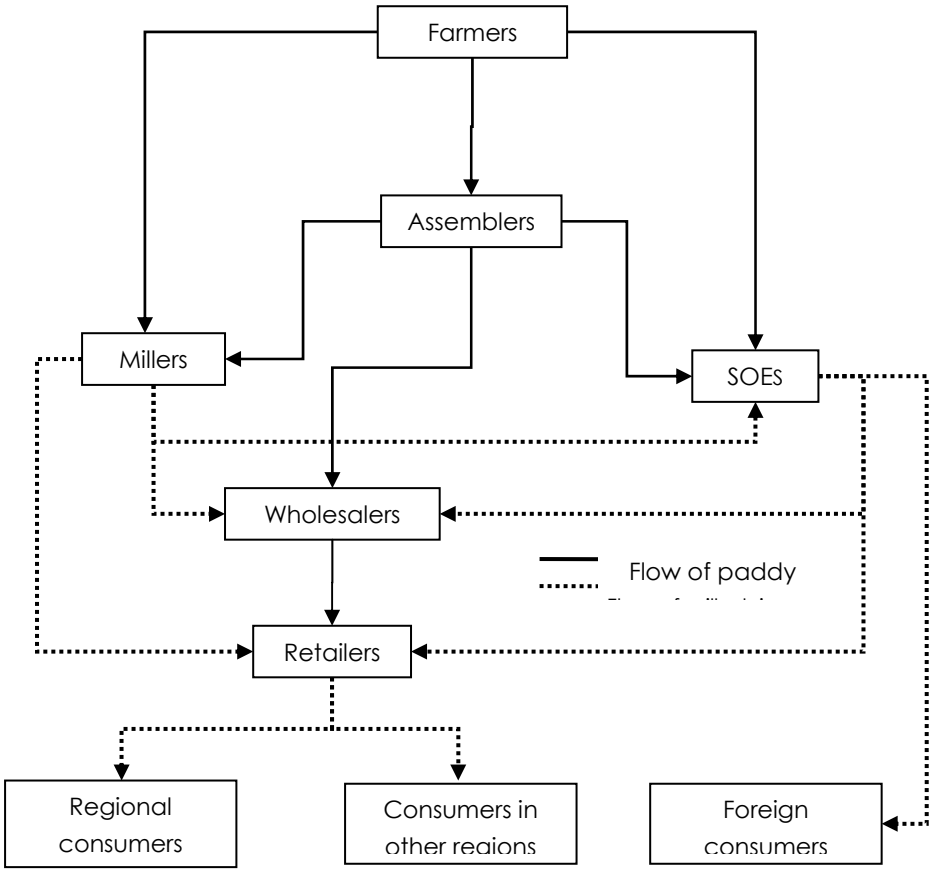


Source: FAOSTAT data, 2006

2.4 Paddy Marketing

Before sale to consumers as milled rice, paddy goes through a process that involves many stages, including checking and sorting, drying and storing, milling, polishing and packaging, storage and transportation (Luu, 2003). There are various channels used for marketing paddy and rice in Vietnam (Figure 7). According to Minot and Goletti (1999), more than two thirds of paddy is sold to the assemblers, of whom 95 percent are private firms. Most of the remainder goes to small-scale millers for farmers' home consumption, while a small share is bought directly by larger millers. The assemblers then either have the paddy custom milled or sell paddy to medium and large-scale millers. The assemblers and millers then sell the milled rice on to the wholesalers and retailers. State-owned enterprises (SOEs) play a relatively minor role in the within province marketing of paddy and rice but control the long-distance trade in rice ad export market. SOEs consist of provincial and regional food companies (of which Vinafood I in the North, and Vinafood II in the South are the most important). Until recently only the SOEs were permitted to export rice to other countries, and they still dominate the export trade.

Figure 7: Vietnam's paddy and rice marketing channels



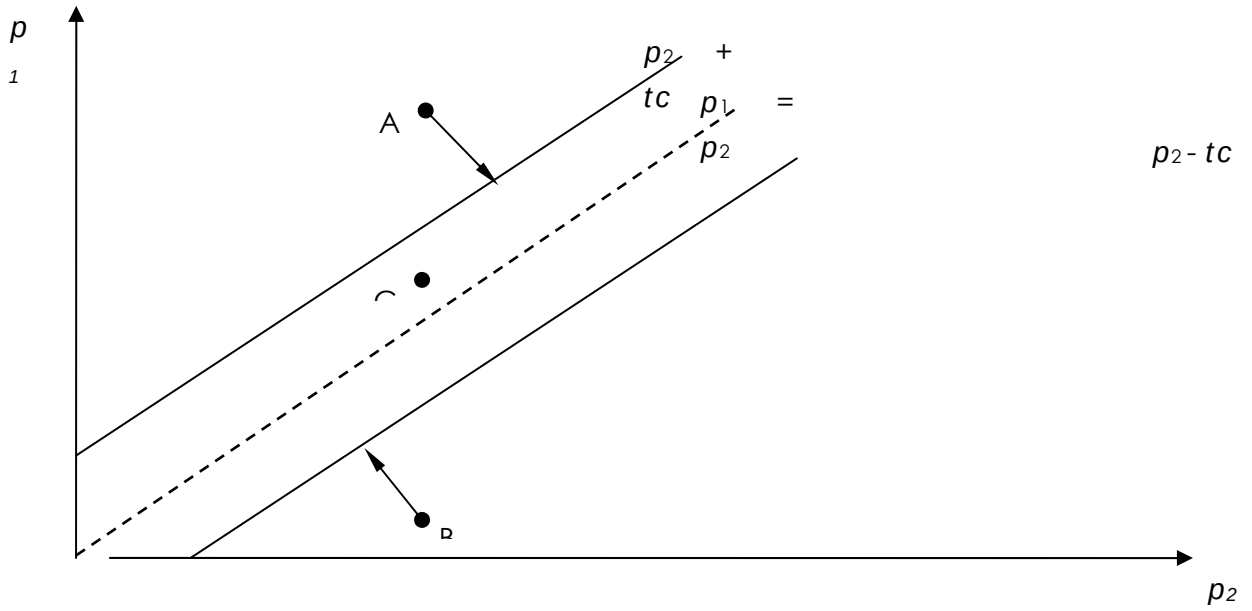
Source: Drawn by the authors, based on Luu (2003) and Minot and Golletti (1999)

3 Modelling and Testing for Market Integration with Transfer Costs

Tests of spatial market integration using time series data on food price dates back to the 1960s. The first tests arose from Lele's (1967) and Jones' (1968) analyses of staple food prices in India and Nigeria, respectively. The two authors estimated the contemporaneous correlations between price series in two markets in different locations. When the correlations were greater than 0.7 or 0.8, they concluded that price movements were close enough for the two markets to be considered as being spatially integrated. The cut-off point used for deciding if markets were spatially integrated was, however, arbitrary and no consideration was given to whether or not the price series were stationary or non-stationary. Nonetheless, many of the subsequent (more rigorous) econometric models used for testing spatial market integration rely on the same idea of testing how closely prices move together. In particular, models of the Law of One Price (Isard, 1977; Richardson, 1978) and the Ravallion model (Ravallion, 1986) are both extensions of the correlation idea. Cointegration tests have also been used to test for the co-movement of food prices and long-run market integration (Alexander and Wyeth, 1991; Dawson and Dey, 2002).

A growing body of the spatial market integration literature stresses the importance of transfer costs. Basically, transfer costs introduce a wedge between prices at separate locations, resulting in a non-linear relationship between such pairs of prices. The parity bounds model developed by Sexton, Kling and Carman (1991) and Baulch (1997) explicitly take account of the non-linear price relationship in spatially distributed markets that is caused by transfer costs. Furthermore, much recent research focuses on an explicit modeling of threshold effects when testing the Law of One Price. See, for example, Goodwin and Piggott (2001), Meyer (2004), and Sarno, Taylor and Chowdhury (2004).

Figure 8: Prices in two markets with transfer costs



Transfer costs are important both for modeling spatial market integration as they imply a potential bias in estimators based on linear models. Consider, for example, a relationship between two paddy markets, 2 and 1. In the absence of transfer costs, spatial market integration will imply that the paddy prices in the two markets should be equal, so $p_1 = p_2$. In Figure 8 such a market integration situation is illustrated by the 45-degree line. Now, if there are transfer costs of *tc* per kilogram of paddy, there need not be any trade between the markets when $p_2 - tc < p_1 < p_2 + tc$ because the transfer costs make inter-market trade unprofitable. This "no-trade" region suggests that prices respond differently in the three regimes defined by the upper and lower thresholds, $p_2 + tc$, $p_2 - tc$. If p_1 is above $p_2 + tc$ (for example, point A in Figure 8) one would expect a trade flow from market 2 to market 1, leading to a price increase in market 2 and a price decrease in market 1. Likewise, if p_1 is less that p_2 - *tc* (for example, point B in Figure 8) trade between the markets should lead to a price decrease in market 2 and a price increase in market 1. These effects are not changed by the presence of transfer costs. However, prices will only adjust when trade is profitable. When p_1 is between the $p_2 - tc$ and $p_2 + tc$ lines in Figure 8 (for example, point C), then there is no trade inducing market forces to equate the paddy prices in the two markets. We describe this as the no-trade regime. It follows that the overall correlation between the prices may be low if prices are often in this no-trade regime. Hence, if we use a linear model when there are positive transfer costs, we are likely to underestimate the price correlations in the regimes in which trade is profitable because these correlations are confounded by the possible lack of correlation in the no-trade regime.

The main problem with threshold models of spatial market integration is that in the absence of information on transfer cost the estimation procedure is rather complicated, particularly with two thresholds.[2] To overcome this problem, in this chapter we use outside information on transfer costs to formulate a threshold variation of Ravallion's well-known dynamic model of spatial market integration (Ravallion, 1986). Specifically, we use fixed and known threshold values computed from additional information (collected from traders and transporters) about transfer costs to model the three regimes described above. The remainder of this section shows how this model is formulated and presents the testing sequence we use to analyze the various forms of spatial market integration.

Consider Ravallion's model of market integration in which price in market 1 (p_{1t}) is conditional on the price in market 2 (p_{2t}), lagged prices (p_{1t-i} and p_{2t-i}) and a set of seasonal dummies (S_t):[3]

$$p_{1t} = d + a_1 p_{1t-1} + a_2 p_{1t-2} + b_0 p_{2t} + b_1 p_{2t-1} + b_2 p_{2t-2} + \phi' S_t + \varepsilon_t \qquad (1)$$

We generalize this model by allowing the constant, the autoregressive parameters and the distributed lag parameters to vary across regimes in the following way:

$$p_{1t} = d^{(s)} + a_1^{(s)} p_{1t-1} + a_2^{(s)} p_{1t-2} + b_0^{(s)} p_{2t} + b_1^{(s)} p_{2t-1} + b_2^{(s)} p_{2t-2} + \phi' S_t + \varepsilon_t \qquad (2)$$

in which $\theta^{(s)} = (d^{(s)},\ a_1^{(s)}, a_2^{(s)}, b_0^{(s)}, b_1^{(s)}, b_2^{(s)})$ are regime dependent parameters defined by

$$\theta^{(s)} = \begin{cases} \theta^{(1)} & \text{if } (p_{1t-l} - p_{2t-l}) \geq tc_1 \\ \theta^{(0)} & \text{if } tc_2 < (p_{1t-l} - p_{2t-l}) < tc_1 \\ \theta^{(2)} & \text{if } tc_2 \geq (p_{1t-l} - p_{2t-l}) \end{cases} \qquad (3)$$

[2] See Hansen (1996, 1997) for a general estimation procedure of threshold models and Hansen and Seo (2002) for estimation of error correction models with threshold effects.

[3] An autoregressive, distributed lag model with two lags appears to give a good description of the paddy price series in the subsequent analysis. Therefore, we present the model with two lags rather than a more general model having, say, *k* lags.

where the relationship between the inter-market price spread at lag l and the transfer costs (tc_1, tc_2) determines the regime. For simplicity, we assume that the additive seasonal component in the price series is the same in all three regimes, and we also assume the innovations are iid(0,□^{2}) across the regimes.

The model in (2) can be reformulated as an error correction model allowing for non-stationary and cointegrated prices in the two markets

$$\Delta p_{1t} = \gamma^{(s)}\Delta p_{2t} + \delta_1^{(s)}\Delta p_{1t-1} + \delta_2^{(s)}\Delta p_{2t-1} + \alpha^{(s)}(p_{1t-1} - \beta^{(s)} p_{2t-1} - \mu^{(s)}) + \phi' S_t + \varepsilon_t \quad (4)$$

and the parameters in (2) and (4) are related by:

$$\gamma^{(s)} = b_0^{(s)},\ \delta_1^{(s)} = -a_2^{(s)},\ \delta_2^{(s)} = -b_2^{(s)}$$
$$\alpha^{(s)} = -(1 - a_1^{(s)} - a_2^{(s)}),\ \beta^{(s)} = \frac{b_0^{(s)} + b_1^{(s)} + b_2^{(s)}}{1 - a_1^{(s)} - a_2^{(s)}},\ \mu^{(s)} = \frac{d^{(s)}}{\alpha^{(s)}} \quad (5)$$

It is worth noting that the error correction term in (4) is a "generalized" inter-market price spread $w_t = p_{1t} - \beta^{(s)} p_{2t} - \mu^{(s)}$, which simplifies to the standard inter-market price spread when $\beta^{(s)} = 1$.

The threshold error correction in equation (4) can be used to test most of the interesting hypotheses about spatial market integration including the Law of One Price and Ravallion's tests for market segmentation and long-run market integration. To ensure valid inference, our first step is to test for stationarity of the individual price series and of the generalized inter-market price spread.[4] Conditional on the existence of cointegration, we then test the hypotheses of interest for spatial market integration using the threshold error correction model.

The first hypothesis to be tested is one of *market segmentation*. Based on Ravallion (1986), we define market segmentation as a model in which the price in market 2 does not Granger-cause the price in market 1 and, in addition, that there is no instantaneous correlation between the price series—in any regime. Hence, in terms of parameter restrictions we say that the markets are segmented if in equation (4):

$$H_0^{(1)} : \alpha^{(s)} = 0, \delta_2^{(s)} = 0, \gamma^{(s)} = 0, \quad \text{for all } s = 0,1,2. \quad (6)$$

If market segmentation is rejected, we next test for the number of thresholds. This is done in three steps. Specifically, we formulate and test the three hypotheses

$$H_0^{(2a)} : \theta^{(1)} = \theta^{(0)}, \quad H_0^{(2b)} : \theta^{(2)} = \theta^{(0)}, \quad H_0^{(2c)} : \theta^{(1)} = \theta^{(2)} = \theta^{(0)}. \quad (7)$$

If the first two hypotheses are rejected we infer that there are two thresholds. In contrast, if all three hypotheses are accepted we infer that the model is linear.

Once the number of thresholds is established, we can further reformulate the error correction model to allow for freely varying long-run parameters in each regime

$$\Delta p_{1t} = \gamma^{(s)}\Delta p_{2t} + \delta_1^{(s)}\Delta p_{1t-1} + \delta_2^{(s)}\Delta p_{2t-1} + \alpha^{(s)} p_{1t-1} + \pi^{(s)} p_{2t-1} + d^{(s)} + \phi' S_t + \varepsilon_t \quad (8)$$

Subsequently, we test for *long-run market integration*, which is the hypothesis

$$H_0^{(3)} : \alpha^{(s)} = -\pi^{(s)} \quad \text{(equivalent to } \beta^{(s)} = 1) \quad (9)$$

[4] We test for stationarity of the price series and the price spread in the simplest possible way using the ERS unit-root test (Elliot, Rothemberg and Stock, 1996). As we do not include thresholds when testing stationarity of the generalized inter-market price spread, we are effectively assuming the long run parameters are constant across regimes when testing for stationarity. While the assumption of regime independent long run parameters is a restriction on the model, we consider this to be a quite plausible initial restriction and later allow for differences in the long-run parameters.

in equation (8). This is equivalent to testing $\beta^{(s)} = 1$ in equation (4). Clearly, the number of hypotheses tested depends on the number of thresholds, so our tests for long-run market integration are regime dependent. Note that with two thresholds, the information about the long run parameters may be weak in particular in the inner (no-trade) regime.[5]

If long run integration is accepted in a regime, we impose the restriction by using the lagged inter-market price spread as the error correction term (*i.e.*, $\alpha^{(s)} p_{1t-1} + \pi^{(s)} p_{2t-1}$ is replaced by $\alpha^{(s)}(p_{1t-1} - p_{2t-1})$ in equation (8). If long-run market integration is not accepted it makes little sense to carry on testing stronger versions of the Law of One Price. Hence, the following hypotheses and tests are only reported if the hypothesis of long-run market integration is accepted in at least one regime.

Before testing for the strong version of the Law of One Price we look at a weaker restriction, which is akin to the weak market efficiency hypothesis in the financial markets literature. This is done by formulating a hypothesis of *common dynamics*. We define common dynamics to be the restriction

$$H_0^{(4)} : \delta_1^{(s)} = \delta_2^{(s)} \qquad (10)$$

If the hypothesis is accepted, the only past information needed to predict the price in market 1 is the inter-market price spread in previous periods. Adding information on past values of individual prices will not improve the prediction of the price in market 1.

Finally, given acceptance of long-run market integration and common dynamics it is interesting to test for the strong version of the *Law of One Price*. The hypothesis is formulated as

$$H_0^{(5)} : \gamma^{(s)} = 1, \text{ and } \delta_1^{(s)} = \delta_2^{(s)} \qquad (11)$$

This involves testing jointly that the prices in the two markets have common dynamics and that the conditional correlation between the two prices is one. In this case, a unit change in prices in market 2 will be associated with a one unit change in prices in market 1 within the current time period. This is similar to Ravallion's (1986) test for short-run market integration (strong form) and implies that the Law of One Price holds contemporaneously.[6]

The test for Law of One Price is the final test in the sequence. If this test is not rejected in the regimes with trade options, we consider the markets to be fully integrated even if the hypothesis is rejected in the no-trade regime.

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[5] It should also be noted that the term 'long-run market integration' may be somewhat misleading in this model as acceptance of the hypothesis in some regimes does not imply that prices will eventually be equal in the absence of shocks. However, if the hypothesis is accepted in all regimes, then the standard notion of long-run market integration applies.

[6] If the Law of One Price is not rejected in a regime, the model for that regime reduces to

$$\Delta p_{1t} = \Delta p_{2t} + \delta_1^{(s)} \Delta(p_{1t-1} - p_{2t-1}) + \alpha^{(s)}(p_{1t-1} - p_{2t-1} - \mu^{(s)}) + \phi' S_t + \varepsilon_t$$

and this implies that the loading parameter $\alpha^{(s)}$ is no longer of "special interest" for describing the dynamics of price adjustment. The differences between prices in markets 1 and 2 will, in this regime, be a white noise process, given by ε_t.

4 Data on Paddy Prices, Transfer Costs and Time Series Properties

4.1 Data

The paddy price data used in this chapter were provided by Information Center for Agriculture and Rural Development (ICARD) and can be publicly accessed online.[7] Prices of paddy (and some other agricultural commodities) are collected on Fridays at public markets in sixteen provinces. Based on the weekly data, monthly price series are computed by taking averages. It is worth considering the appropriateness of using monthly series in testing spatial market integration. Luu (2003) argues that average monthly data is inappropriate when analyzing rice market integration in the Mekong River Delta because these prices do not reflect the daily prices on which traders make their arbitrage decisions. However, in the weekly price series we have looked at there are several long periods in which prices do not change at all in almost every market. Such constancy of prices will invalidate a statistical analysis that is based on an assumption of independent and identically distributed innovations that follow a continuous distribution. Moreover, the use of weekly data is problematic due to the need to interpolate numerous missing values. For these reasons we have chosen to analyze the monthly data instead of the weekly data. However, since one month appears too long a time lag for traders to make their arbitrage decisions we construct the regime dummies using a lag of half a month.[8]

For paddy prices, monthly data are fully available across eight markets from January, 1993 to May, 2006. Given the fact that inflation has changed substantially over the period, we adjust for its effects by deflating nominal paddy prices using the Consumer Price Index. Accordingly, all paddy prices to be used in the analysis were converted into constant January 1993 prices. Four out of the eight markets are located in the Red River Delta (Ha Noi, Bac Ninh, Nam Dinh, and Thai Binh). The other four markets are located in the Mekong River Delta (Can Tho, An Giang, Tien Giang, and Ca Mau). As can be seen in Figure 9, all these provinces cluster round the 1A National Road, which is the main road connecting the North, Center and South of Vietnam. National roads also connect Ha Noi with Bac Ninh, Nam Dinh and Thai Binh and Can Tho with An Giang and Tien Giang. In both the Red River and Mekong River deltas, rivers are also used for the transportation of paddy: one of the Mekong River's branches, the Hau Giang, connects An Giang with Can Tho.

[7] ICARD is an institution under the Ministry for Agriculture and Rural Development (MARD). See the website: http://www.agroviet.gov.vn.

[8] We do this by taking an average of the inter-market price spreads at time *t* and *t-1. i.e.,* $\lambda(p_{1t} - p_{2t}) + (1-\lambda)(p_{1t-1} - p_{2t-1})$ where λ = 0.5. Setting λ equal to 0.25 or 0.75 produces similar results.

Figure 9: Location and Transportation Links between the Eight Paddy Markets

Source: Drawn by the authors using ArcGIS

In addition to price series, we also need estimates of transfer costs to determine the thresholds used in the estimation of the threshold error correction model defined by equations (4)and (8). Transfer costs represent the total observed costs of moving paddy from one market to another, and include both fixed costs and variable costs elements. Data on these fixed and variable costs were collected through interviews with traders and lorry drivers. The fixed cost element comprises loading and unloading costs plus specific trade taxes (where applicable). The variable cost element comprises pure freight costs, which vary with the distance traveled and road conditions, and *ad valorem* trade taxes. From our interviews with traders, we have estimated the unit cost of transporting one kilogram of paddy over one kilometer. We assume that these unit costs are constant in real terms and do not vary according to the distance between markets.[9] So to estimate the transportation costs between two markets, we simply multiply the unit costs of transportation by the distance between markets. Finally, since it is rice rather than paddy which is usually transported between provincial markets, we also have to adjust transfer costs by the milling ratio between paddy and rice. Accordingly, our estimates of transfer costs between markets i and j (tc_{ij}) are based on the following expression:

$$tc_{ij} = \frac{20 + 0.45 \times D_{ij}}{0.65} \qquad (12)$$

[9] In theory, unit transportation costs should decline with distance traveled. However, our discussions with traders and transporters indicate that this is a very imprecise relationship with freight rates often remaining constant between nearby markets.

where 20 (Dong) is the fixed cost of loading and unloading one kilogram of rice, 0.45 (Dong) is the unit cost of transporting 1 kilogram of paddy for 1 kilometer, D_{ij} is the distance following the main road between market *i* and market *j* and 0.65 is the milling (rice-paddy conversion) ratio.

Table 5 presents our estimated transfer costs between the market pairs in our analysis. Within each region (North or South) we assume that transfer costs from market *i* to market *j* is the same as from market *j* to market *i*. However, our discussions with traders suggest that this assumption does not hold between markets in the North and South of Vietnam, since the demand for moving goods from the South to the North is substantially higher than in the opposite direction. Our discussions with traders indicate that premium on moving produce from the South to the North is approximately 25 percent, so this is added to our estimates of transfer costs between Can Tho and Ha Noi. To be consistent with the paddy price series, we have then deflated our transfer cost estimates to constant January 1993 terms using the Consumer Price Index.

Table 5: Estimated Transfer Costs Between Market Pairs

Market 1	Market 2	Distance (km)	Estimated Transfer Cost
Ha Noi	Bac Ninh	25	23
Ha Noi	Nam Dinh	85	43
Ha Noi	Thai Binh	95	46
Ha Noi	Can Tho	1794	606
Can Tho	Ha Noi	1794	758
Can Tho	An Giang	65	36
Can Tho	Tien Giang	115	53
Can Tho	Ca Mau	213	85

Notes: The transfer costs are measured in Dong per kg in January 1993 prices.

4.2 Descriptive Statistics and Tests for Stationarity and Cointegration

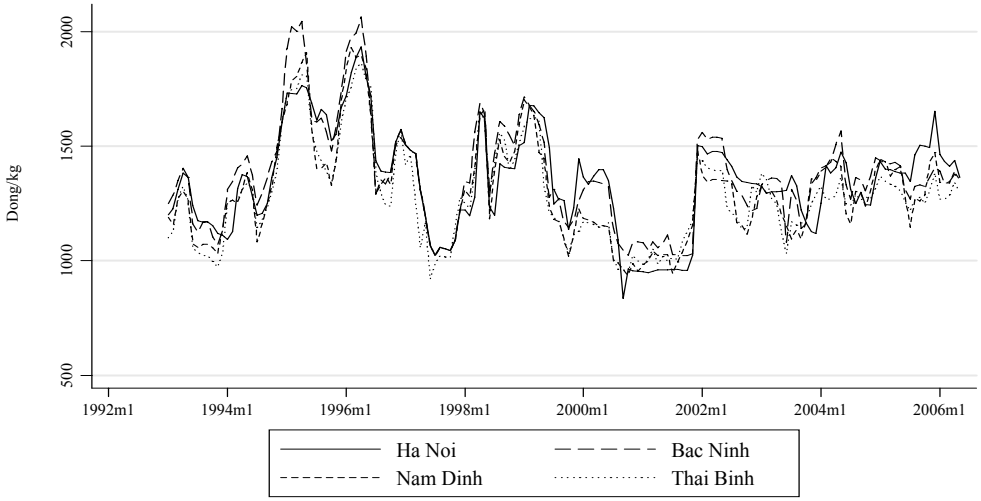
Table 6 shows means, medians, and other basic statistics of the monthly price series. We note that, on average, prices in the northern provinces are lower than those in the southern provinces. Among the eight markets in our sample, An Giang and Can Tho have the lowest paddy prices. This low level of prices may well reflect that An Giang and Can Tho are the largest paddy producers in Vietnam. Another interesting result in Table 6 is that, on average, paddy prices in Ha Noi were lower than in Bac Ninh. To this end it should be noted that the median price in Bac Ninh is lower than the median price in Ha Noi. **Figure**s 10 and 11 show the monthly paddy prices in the four provinces in the North and the four provinces in the South, respectively. Based on the plots, the overall impression is that there is a fairly high co-movement in prices in the two regions. Furthermore, there is no clear trend in the series; on the other hand there is also no clear mean reversion tendency.

Table 6: Descriptive Statistics for the Paddy Prices

Market	Mean	Median	Std. dev.	Min	Max
North					
Ha Noi	1348.89	1363.12	219.95	836.11	1934.56
Bac Ninh	1375.96	1350.53	232.18	1021.99	2063.53
Nam Dinh	1308.69	1302.00	222.92	935.51	1930.30
Thai Binh	1286.03	1267.31	212.27	919.78	1862.91
South					
Can Tho	1090.79	1093.13	137.32	765.33	1412.56
An Giang	1083.93	1083.61	155.86	716.89	1487.86
Tien Giang	1112.76	1112.13	149.78	755.10	1560.78
Ca Mau	1101.36	1106.82	166.43	729.56	1668.21

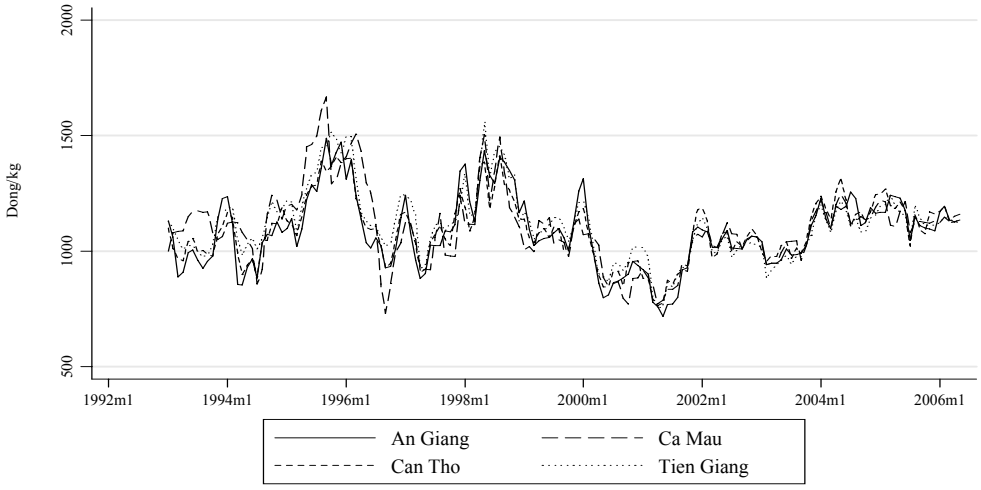
Notes: There are 161 observations in the sample (1993m1-2006m5). Prices are measured in terms of Dong per kg in January 1993 prices.

Figure 10: Monthly Paddy Prices in the Northern Provinces (1993m1-2006m5)



Source: Drawn by the authors using price data from
the Information Center for Agriculture and Rural Development

Figure 11: Monthly Paddy Prices in the Southern Provinces (1993m1-2006m5)



Source: Drawn by the authors using price data from
the Information Center for Agriculture and Rural Development

We next examine the time series properties of the prices by testing for stationarity using Elliott, Rothenberg, and Stock's (1996) modified Dickey-Fuller test for unit roots.[10] The ERS test involves expressing a time series $y_t = y_1, ..., y_T$ as:

$$\begin{aligned} y_t &= \tau_t + \eta_t, \\ \eta_t &= \rho\eta_{t-1} + \nu_t \end{aligned} \tag{13}$$

where τ_t is a deterministic component, ν_t is a stationary process with zero mean, and ρ is the autoregressive parameter. The null hypothesis that $\rho = 1$ implies that the series y_t has a unit root (i.e., is integrated of order one, I(1)) and it is tested against the alternative $|\rho| < 1$, implying that y_t is stationary.

The ERS procedure works as follows. First, a local unit root is assumed by fixing the parameter $\bar{\rho} = (1 + \bar{c}/T)$.[11] The parameter is used to form quasi-differences of the series: $\{y_1, y_2 - \bar{\rho}y_1, y_3 - \bar{\rho}y_2, \ldots, y_T - \bar{\rho}y_{T-1}\}$ and the quasi-differences are regressed on corresponding quasi-differences of the deterministic components (constant, trend, and so on). Subsequently, a standard ADF-test is used to test if the non-deterministic component of the series (η_t) has a unit root.

Table 7 reports the results of testing for unit roots in each price series using the ERS test with a trend as the dominating deterministic component. The number of lags is chosen using the Schwarz information criterion. All price series in the northern markets have unit roots in levels but not in first differences, hence they are I(1). However, in the southern markets the price series from An Giang, and Tien Giang do not seem to have unit roots when tested at the 5 percent level of significance though they do have unit roots at the 1% level of significance. The test statistic for Ca Mau lies on the boundary of accepting or rejecting the unit root at the 5 percent level. Like the North, null hypothesis of a unit root is rejected for the first differences of the prices in the South. In sum, we conclude that, all the price series are integrated of order 1.

Table 7: Unit-Root Tests

	First differences		Levels	
Market	Optimal lag	Test statistic	Optimal lag	Test statistic
North				
Ha Noi	1	-10.31	2	-2.21
Bac Ninh	1	-8.42	1	-2.34
Nam Dinh	1	-8.91	1	-2.35
Thai Binh	1	-8.97	1	-2.34
South				
Can Tho	4	-3.06	2	-2.48
An Giang	1	-10.13	1	-3.22
Tien Giang	1	-9.75	1	-2.96
Ca Mau	3	-3.32	1	-3.52

Notes: The test for unit-roots is the Elliot, Rothenberg and Stock (1996) test with seasonal dummies included. The 1%, 5%, and 10% critical values for levels are -3.51, -2.91, and -2.63, respectively. The 1%, 5%, and 10% critical values for first differences are -2.59, -2.04, and -1.72, respectively.

[10] This test is also known as the DFGLS test. Basically, this test follows the augmented Dickey-Fuller procedure, but, as stated in Baum and Sperling (2001), it has better power than the ADF-test in small samples.

[11] In most cases, τ_t is zero, a constant or a linear trend. $\bar{c}$ is set to -13.5 if the model contains a linear trend, and -7 if it does not.

Next we test for stationarity of residuals from pair-wise Engle-Granger-type cointegrating regressions and stationarity of the inter-market price spreads (Table 8). We expect to reject the null hypothesis of a unit root in the residuals for the assumptions underlying our general threshold error correction model to hold. In general, we can strongly reject the hypothesis of a unit root and conclude that there is cointegration between all market pairs. However, we cannot reject the null hypothesis of non-stationarity for the residuals of regressing Can Tho on Tien Giang. For the inter-market price spreads, which are used for the error correction terms in the restricted version of our model, we can also reject a unit root for all market pairs at the 5 percent level.

Table 8: Pair-wise Cointegration Tests

	Residuals from Cointegration regressions		Inter-market price spread	
Market pair	Optimal lag	Test statistics	Optimal lag	Test statistics
Ha Noi –Can Tho	1	-3.37	1	3.41
North				
Ha Noi –Bac Ninh	2	-3.69	2	-3.84
Ha Noi – Nam Dinh	1	-5.26	1	-5.33
Ha Noi – Thai Binh	1	-4.19	1	-4.45
South				.
Can Tho - An Giang	2	-5.78	2	-5.65
Can Tho - Tien Giang	3	-2.42	3	-2.38
Can Tho – Ca Mau	1	-4.97	1	-5.56

Notes: The test for unit root is the Elliot, Rothenberg and Stock (1996) test with seasonal dummies included. The 1%, 5%, and 10% critical values for the residuals from the cointegration regressions are -3.43, -2.86, and -2.57, respectively. The 1%, 5%, and 10% critical values for the inter-market price spread are -2.59, -2.04, and -1.72, respectively.

5 Tests for Market Integration

In this Section, we apply the sequential approach to testing for market integration discussed in Section 3 to the eight non-stationary and cointegrated paddy price series described above in order to investigate: (i) whether paddy markets in the North and the South of Vietnam are spatially integrated, (ii) if paddy markets within the North and within the South are integrated, and (iii) if price adjustment within regions are stronger (and faster) than between them.

To investigate whether paddy markets in the North and the South of Vietnam are spatially integrated, we choose Ha Noi to represent the North of Vietnam and Can Tho to represent the South. Ha Noi, the capital city of Vietnam, is the second largest city in Vietnam and it is located close to the centre of the Red River Delta. Can Tho is the major milling and exporting centre in the Mekong River Delta.[12] Having tested if Ha Noi and Can Tho are spatially integrated, we then move on to examining whether the other three markets in the North (Bac Ninh, Nam Dinh and Thai Binh) are spatially integrated with Ha Noi. Then we perform similar tests with Can Tho and the other three markets in the South (An Giang, Tien Giang and Cau Mau). Recall that only when market segmentation is rejected and long-run market integration is accepted, do we move on to testing for common dynamics and the Law of One Price.

[12] Ho Chi Minh City, the major commercial centre and largest city in Vietnam, would have been an alternative choice for the major centre of demand in the South. However, it is not located in the Mekong River Delta and the paddy price data available for Ho Chi Minh City are very incomplete.

Table 9 summarizes the test results for all market pairs. Two thresholds are indicated for all market pairs except for Ha Noi and Can Tho (where no thresholds are detected) and between Ha Noi and Bac Ninh (where there is no statistical difference between the parameters in the above and inside regimes). Market segmentation is also strongly rejected for all market pairs, except for Can Tho and Cau Mau, implying that paddy prices in the demand centers are influenced by paddy prices in the markets in the producing areas

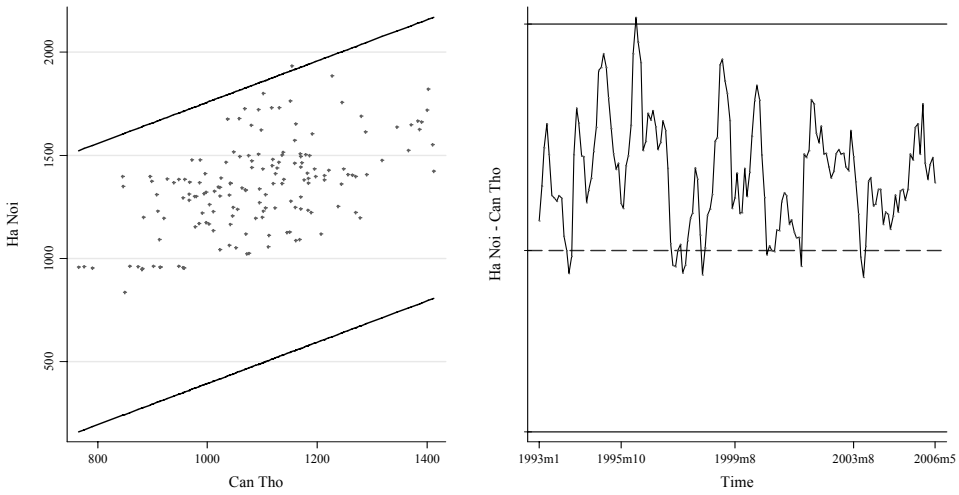
Table 9: Tests for Market Integration

Market pairs	# of thres-holds	Regime Frequencies	Long-run Integration	Common Dynamics	Law of One Price	γ	τ
Ha Noi - Can Tho	0		A	R	R	0.410	-0.149
		[1.00]	[0.287]	[0.009]	[0.000]	(0.105)	(0.040)
North							
Ha Noi - Bac Ninh	1	Above + Inside	A	A	R	0.644	-1.181
		[0.50]	[0.592]	[0.095]	[0.000]	(0.073)	(0.356)
		Below	A	A	R	0.637	-0.606
		[0.50]	[0.071]	[0.632]	[0.000]	(0.082)	(0.096)
Ha Noi - Nam Dinh	2	Above	A	A	R	0.600	-0.437
		[0.42]	[0.853]	[0.446]	[0.000]	(0.084)	(0.105)
		Inside	A	A	A	1	
		[0.37]	[0.208]	[0.990]	[0.741]	(--)	
		Below	A	A	A	1	
		[0.21]	[0.620]	[0.065]	[0.129]	(--)	
Ha Noi - Thai Binh	2	Above	A	A	R	0.495	-0.407
		[0.54]	[0.941]	[0.964]	[0.000]	(0.073)	(0.088)
		Inside	A	A	R	0.779	-1.394
		[0.32]	[0.438]	[0.871]	[0.012]	(0.074)	(0.151)
		Below	A	A	A	1	
		[0.14]	[0.629]	[0.512]	[0.203]	(--)	
South							
Can Tho - An Giang	2	Above	A	A	R	0.733	-1.083
		[0.27]	[0.838]	[0.419]	[0.001]	(0.073)	(0.175)
		Inside	A	A	R	0.859	-1.357
		[0.57]	[0.125]	[0.870]	[0.049]	(0.057)	(0.117)
		Below	A	R	R	0.868	-1.201
		[0.16]	[0.156]	[0.039]	[0.039]	(0.010)	(0.158)
Can Tho - Tien Giang	2	Above	A	A	A	1	
		[0.08]	[0.807]	[0.432]	[0.669]	(--)	
		Inside	A	A	R	0.798	-0.587
		[0.62]	[0.067]	[0.064]	[0.000]	(0.062)	(0.095)
		Below	A	A	R	0.808	-0.947
		[0.30]	[0.243]	[0.779]	[0.010]	(0.066)	(0.172)
Can Tho - Ca Mau	2	Above	A	A	R	0.452	-0.864
		[0.06]	[0.947]	[0.161]	[0.003]	(0.200)	(0.306)
		Inside	R				
		[0.77]	[0.012]				
		Below	R				
		[0.17]	[0.009]				

Notes: R and A indicate the null-hypotheses can be rejected and 'accepted' at the 5% level of significance.
p-values and regime frequencies are given in square brackets. Standard errors of the estimated parameters γ and τ are shown in round brackets.

The finding of no thresholds for Ha Noi and Can Tho requires further comment, as these are the two most important demand centres in the Red River and Mekong River deltas. The absence of a threshold between these markets implies that there is a linear relationship between paddy prices in Ha Noi and Can Tho. As can been seen from the time series plot of price differences on the right hand side of Figure 12, the inter-market prices spread only exceeds estimated transfer costs in 160 of our 161 observations. Under such circumstances one would not expect to observe a high correlation between paddy price changes in Ha Noi and Can Tho, and this is born out by the disparate cross plot of prices on the left-hand side of Figure 12. It is also reflected in the size of the coefficient on contemporaneous price changes (γ) in Can Tho in the unrestricted linear error correction model being 0.410. Furthermore, the loading coefficient (α) on the lagged inter-market price spread indicates that the speed of price adjustment between Ha Noi and Can Tho is rather slow. Put differently, transfer costs between Ha Noi and Can Tho (which are 1,790 kms apart) are sufficiently high to make trade between the two markets unprofitable virtually all of the time. We can therefore conclude that paddy markets in Ha Noi and Can Tho are only weakly integrated which, in turn, suggests there is low integration between paddy and rice markets in the North and South of Vietnam.[13]

Figure 12: Cross Plot of Ha Noi and Can Tho and Time Series Plot of the Inter-market Price Spread with Thresholds given by Estimated Transfer Costs



Source: Drawn by the authors using price data from
the Information Center for Agriculture and Rural Development

In contrast to Ha Noi and Can Tho, thresholds are indicated for all market pairs within the North and within the South of Vietnam. In general, we find two-threshold models, in accordance with the theory. However, for Ha Noi and Bac Ninh, the two geographically closest markets in our series we find no statistical significant difference between the parameters in the regime above the threshold (when the price in Ha Noi is greater than the price in Bac Ninh plus transfer costs) and the no-trade regime. This may reflect Bac Ninh's role as satellite town to Hanoi, with millers and wholesalers shipping to either Hanoi or Bac Ninh but little paddy or rice being traded between the two markets. Hence for this market pair a one threshold model is estimated, with strong co-movement of prices indicated by the γ coefficients (of 0.644 and 0.637) in the two regimes.

Given the results about the number of thresholds we move on to test the hypothesis of long-run market integration for each regime in turn. Long-run integration, which corresponds to a one-unit change in the price in one market eventually translating into a one-unit price change

[13] Recall that the price series used for these tests is for ordinary paddy, so there may still be trade in high quality ('fancy') rice between the South and North of Vietnam.

in the other market, occurs in all regimes in all markets in the North and in all regimes in two of the three markets in the South. The exception is the market pair Can Tho – Ca Mau for which long run integration is rejected both in the no-trade regime and in the below regime (when the paddy price in Ca Mau exceeds the paddy price in Can Tho plus the transfer costs). Long run integration cannot, however be rejected in the upper regime, although the number of observations is very small in that regime, making us reluctant to draw strong conclusions for that regime.

Only when long-run market integration is indicated do we test for common dynamics and the Law of One Price using the restricted version of the threshold error correction model. Generally, for thresholds and market pairs for which long-run integration is indicated, common dynamics are also found.[14] This is not surprising because both cointegration and long-run integration imply the existence of a long-run relationship between paddy prices in the relevant markets. The finding of a common dynamics shows that all necessary information for predicting the future price is contained in the inter-market price spread (weak-form market efficiency).

The Law of One Price is, however, firmly rejected for most market pairs.[15] This is again not surprising as the form of the Law of One Price which is being tested requires both that price changes in the two markets move together on a one-for-one basis within a single period and that the common factor restriction also holds. As can be seen from the last but one column of Table 9, the γ coefficients between contemporaneous prices changes for these regimes and market pairs are all between 0.41 and 0.87, which is indicative of reasonably strong but far from perfect co-movement of paddy prices. Furthermore, for most market pairs, the γ coefficients exceed 0.6 when the inter-market price spread is above the upper or below the lower threshold. From this we may conclude that, when prices between markets are above or below their threshold levels, at least 60 percent of price changes are transmitted between markets within a month.

The final column of Table 9 shows the loading coefficients (α) from the restricted error correction models. As expected, all the αs are negative showing that the inter-market price spreads will converge to their long-run equilibrium values. The absolute sizes of these loading coefficients indicate very rapid 'corrections' in some markets. In particular in the South we find that the inter-market price spreads returns to the no trade region within the following month. In addition, the absolute size of the loading coefficient is much smaller for Ha Noi and Can Tho than for market pairs within the North and within the South. This suggests that prices co-move more strongly when the threshold band is narrow. Put differently, when transfer costs do not prevent trade, spatial arbitrage brings price differentials back to their thresholds quickly. This is confirmed by the time series plots in Figure 13, which shows fairly rapid reversion of the price spreads whenever spreads exceed the transfer costs.

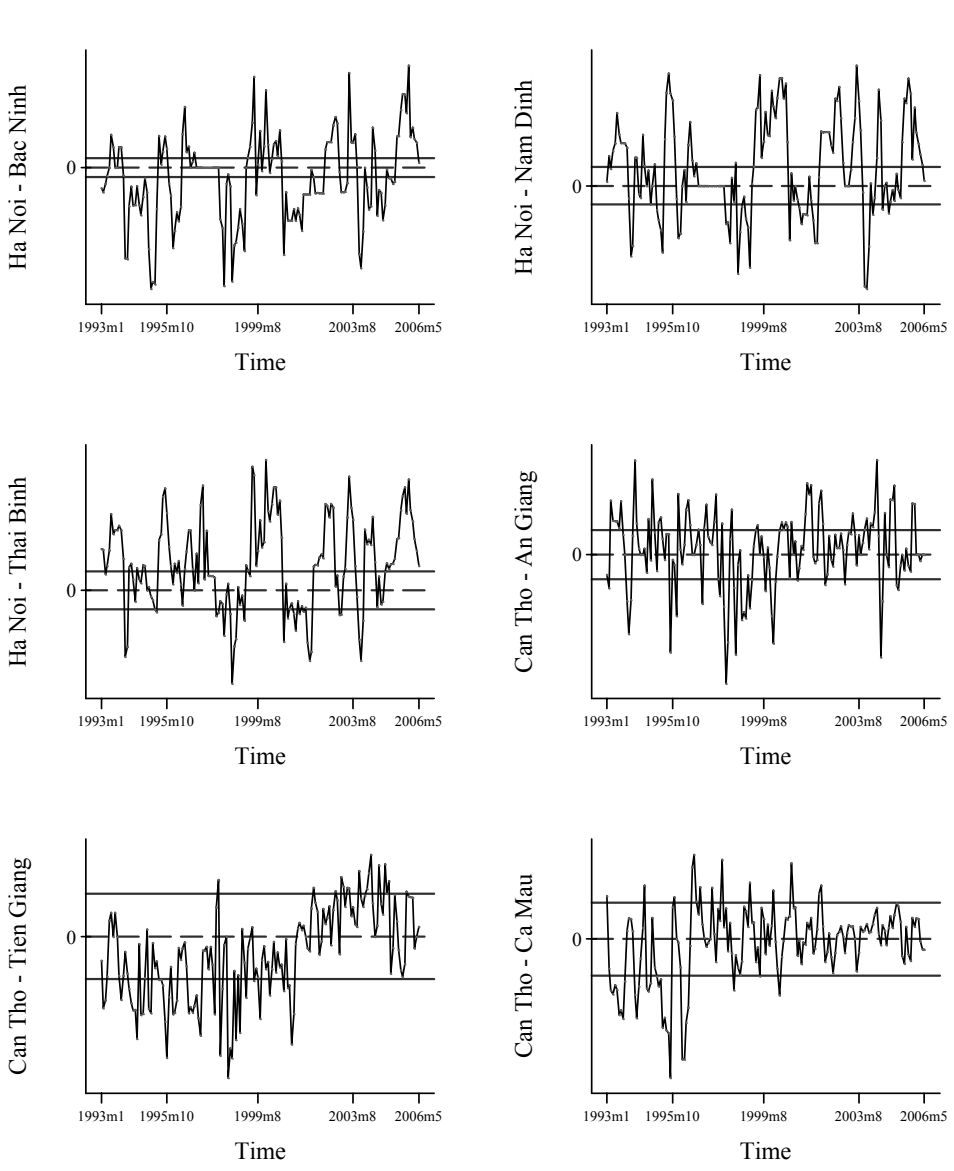
Taken together, our sequential tests for market integration show weak evidence of market integration between paddy markets in the North and South of Vietnam, but stronger evidence of spatial market integration within the North and within the South of Vietnam. While there is evidence of thresholds and long-run integration for most market pairs, the strict version of the Law of One Price does not hold in general even when the price difference between markets exceeds the upper or lower thresholds. Nonetheless, when price spreads are above or below

[14] Here the exception is the lower regime in the Can Tho – An Giang market in which common dynamics is rejected with a *p*-value of 0.04.

[15] When the Law of One Price is not rejected it is often in regimes with a relatively low frequency, such as the lower regime in the Ha Noi – Thai Binh market and the upper regime in the Can Tho – Tien Giang market. However, we find the Law of One Price to hold in two regimes in the Ha Noi – Nam Dinh market suggesting a close integration of this market pair.

the relevant thresholds, a large fraction of the price changes are transmitted between paddy markets within a very short period of time. The extent and speed of price transmission is generally faster in paddy markets located in the South.

Figure 13: Time Series Plots of the Inter-market Price Spreads with Thresholds given by Estimated Transfer Costs



Source: Drawn by the authors using price data from
the Information Center for Agriculture and Rural Development

6 Conclusion and Policy Implications

There has been very little research on food market integration in Vietnam. This chapter aims to help fill this gap by focusing on the spatial integration of paddy markets in the Red River and Mekong River deltas. The empirical model developed uses estimates of transfer costs to generalize the well-known Ravallion model to allow for the possibility of threshold effects. A sequential testing strategy is then developed which progressively tests for market segmentation, the number of thresholds, long-run market integration, common dynamics and (the strict version of) the Law of One Price within an error-correction framework.

To determine whether an error correction framework is appropriate, we first test our eight monthly paddy price series for non-stationary and cointegration using the Elliot, Rothenberg and Stock version of the Dickey-Fuller test. All paddy price series are found to be non-stationary and cointegrated indicating that a long-run relationship exists between market pairs and that an error-correction formulation of our threshold model is appropriate.

When the unrestricted version of this model is estimated, we find weak evidence of market integration between paddy markets in the North and South of Vietnam and an absence of threshold effects. However, there is evidence of both threshold effects and stronger forms of spatial market integration for paddy markets within the North and within the South. Specifically, convergence towards the relevant thresholds and informational efficiency hold for most market pairs, with at least 60% percent of price changes being transmitted between markets within one month whenever price spreads exceeds their upper or lower thresholds. The extent and speed of price transmission within regional paddy markets is generally faster in the South than the North of Vietnam. However, the instantaneous version of the Law of One Price, which requires full price adjustment occur within a month, only holds for a few regimes and market pair.

The policy implications of these results flow from the answers to our three initial questions. First, since there is limited evidence of integration between paddy markets in the North and South of Vietnam, national level policies cannot be relied upon to stabilize or support paddy prices. Instead, agricultural policies need to be designed and implemented with the specific production, consumption and marketing characteristics of northern and southern Vietnam in mind. Second, since there is evidence of market integration within the Red River and Mekong River deltas, paddy markets within these regions can be relied upon to transmit price signals between deficit and surplus areas relatively well. This is good news as it should help agricultural producers to specialize according to comparative advantage and promote investment and growth in the rural areas. Third, since the speed and extent of price transmission is relatively rapid within the North and within the South of Vietnam, the private sector trade can be relied upon to transfer rice and paddy between markets in an efficient manner. If, however, large demand-supply imbalances were to emerge between the North and South, transfer costs are likely to prevent private sector trade taking place and the public sector might need to intervene to ensure adequate supplies in the short-term. Such interventions would, however, need to be implemented in a consistent and market friendly way to avoid destabilizing and distorting an essentially well integrated and competitive paddy marketing system.

Finally further research is needed to examine the robustness of our results to different assumptions about threshold costs and investigate where and how paddy and rice price formation takes places (including the influence of the rice export market). There is also a need to collect better and more frequent data on paddy and rice prices in different locations and stages in the marketing chain, so that the vertical dimensions of market integration can be examined.

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