Article

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Are Pakistan's Rice Markets Integrated Domestically and With the International Markets?

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Abstract

We analyze whether Pakistan has become one domestically integrated rice market and whether Pakistan's rice markets are integrated with the international markets, using monthly data from 1994 to 2011. During this period, major policy shifts took place. In 2002, Pakistan terminated the price support policy; in 2002-2004 export subsidies were introduced, and in 2008, a minimum export price policy was adopted. We compare the degree of integration before and after 2002. We find that most of the regional rice markets in Pakistan are integrated domestically. Pakistan's rice markets are also integrated with the international markets, using prices in Thailand and Vietnam as benchmarks. The price support policy abolition seems to have contributed to greater domestic integration, while the subsequent export policies seem to have decreased the extent of Pakistan's integration with the international markets. However, although Pakistan's rice markets generally are domestically integrated as well as integrated with the international market, price adjustments are quite slow. Thus, only 3% to 11% of deviations from long-run equilibrium are adjusted on a monthly basis, indicating that a shock in international markets takes several months to be fully transferred to prices in Pakistan.

Keywords

rice markets, cointegration, trade policy, Pakistan

Introduction

Well-functioning domestic and international agricultural commodity price transmissions play an important role for efficient resource allocation and economic growth. Slow and imperfect price transmissions leave producers and consumers to make decisions based on prices that do not reflect their real social costs and benefits, leading to slow economic growth (World Bank, 2012b). An understanding of spatial market integration is important to formulate good economic policies (Dutoit, Villafuerte, & Urrutia, 2009; Moser, Barrett, & Minten, 2009; Varela, Aldaz-Carroll, & Iacovone, 2012). Spatial market integration refers to both short-term comovements and long-run relationships among prices. It is defined as the smooth transmission of price signals and information across geographically separated markets (Goletti, Ahmed, & Farid, 1995). Market integration can also be defined as a measure of the extent to which demand and supply in one location are transmitted to another (Negassa, Meyers, & Maldhin, 2003). Price differences beyond what can be explained by transportation and transaction costs indicate inefficient arbitrage and possibly the existence of market power. If markets are not well integrated, this often reflects the presence of infrastructural and institutional bottlenecks that interfere with the efficient flow of goods and prices between markets (Goletti & Babu, 1994).

Investigating price transmission from the international to the domestic market, and integration among domestic markets within a country helps governments in formulating effective polices regarding investments in infrastructure and decisions aimed at improved food security and reduced poverty. Regional and international price differences and spatial price dynamics provide important information for public market regulation and intervention, as well as information to producers and consumers when making decisions regarding resource allocation. Weak market integration may convey incorrect signals to both producers and consumers (Alexander & Wyeth, 1994; Dawe, 2008; Dutoit et al., 2009; Varela et al., 2012).

Rice is the basic staple food for about half of the world's population. International trade in rice is thin, with only about 5% to 7% of total world production being traded globally (Childs & Baldwin, 2010; Razzaque & Laurent, 2006; "Rice:

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Asia's Rice Bowls," 2011). In Asia, domestic policies basically ensure self-sufficiency in many countries. The major exporters of milled rice include Thailand, Vietnam, Pakistan, India, China, the United States, and Italy. However, two exceptional rice trading nations are Pakistan and Thailand due to their low domestic consumption, which is less than 50% of their total production (Childs & Baldwin, 2010).

The thin nature of the world rice market may generate local price patterns and excessive local volatility. Protectionist trade policies such as regulated prices, procurement and government storage, import tariffs, export subsidies, and export taxes adopted by importers and exporters of rice may strengthen price hikes and volatility in rice markets (Childs & Baldwin, 2010; Razzaque & Laurent, 2006; "Rice: Asia's Rice Bowls," 2011; Wailes, 2005).

Rice is an important food and cash crop within Pakistan's agricultural industry, being the second largest staple food crop after wheat and the second largest export item after cotton and cotton products (Government of Pakistan [GoP], 2011). Pakistan ranks 12th in paddy rice production and 4th in milled rice exports in the world. Paddy rice contributes 1.3% to world production, and exports of milled rice account for 10.9% of total world rice exports (United Nations, Food and Agriculture Organization [UNFAO], 2010). Two main varieties of rice, International Rice Research Institute (IRRI) and Basmati, are produced. In this study, we use monthly prices in the major IRRI rice markets in Pakistan, whereas the free on Board (FOB) price of Thai 5% broken rice (a close substitute for IRRI rice) is used as an international benchmark price[1] to test the level of market integration between domestic and international markets. In addition to export prices for Pakistan, export prices from Thailand and Vietnam are used to analyze international market integration. Both Thai and Vietnam rice prices have been major international benchmarks. Earlier studies such as Mushtaq, Abbas, Abedullah, and Ghafoor (2006) and Ghafoor and Aslam (2012) focused mainly on the market for Basmati rice in Punjab province. The present study uses the price of IRRI rice—a species with higher yields, production, and exports—to analyze the effects of the support price policy that was ended in 2002, export subsidies between 2002-2003 and 2003-2004, and minimum export price policies in 2008, and a comparison of market integration before and after 2002.

An Overview of the Rice Sector in Pakistan

Pakistan being a developing country with an agro-based economy has 42% of its labor force working in agriculture, which accounts for 23% of its gross domestic product (GDP). Rice production covers about 20% of the total cropped area for food grain production in the country.[2] It accounts for almost 6% of the value added in agriculture and contributes 1.3% of GDP. About 40% to 50% of the rice produced in Pakistan is exported because of the relatively low annual per capita domestic consumption of about 10 kg (Anwar, 2004; GoP, 2011). This also explains higher exports of IRRI rice compared with Basmati rice, as consumption of Basmati rice is higher than that of IRRI rice. The marketing chain is composed of domestic producers, village dealers, commission agents, wholesalers, retailers, processors, and exporters before reaching domestic and international consumers.

Punjab province is a major producer of Basmati rice, whereas Sindh province is a major producer of IRRI rice. There was no Basmati production in Sindh province until 2008, and only a very small area was allocated subsequently. Although the area under total rice cultivation has varied by 25%—between 2.1 and 2.6 million hectares—production nearly doubled between 1994 and 2011, reaching 7.1 million tons. The area under basmati rice cultivation varied between 1.3 and 1.7 million hectares, while production of Basmati rice fluctuated between 1.2 and 3.1 million tons. The area under cultivation and the production of IRRI rice ranged between 0.62 and 0.92 million hectares, and between 0.3 and 3.0 million tons, respectively. Despite the lower area under IRRI rice cultivation, its production remained higher than Basmati because of its high yield per hectare. The average yield of IRRI and Basmati production was 2,468 and 1,208 kg per hectare, respectively, from 1993 to 1996; yet it was 2,931 and 1,737 kg per hectare from 2008 to 2011. During 2001-2011, total exports of rice varied between 1.58 and 4.18 million tons, with Basmati and non-Basmati (mainly IRRI6 and IRRI9)[3] exports varying between 0.55 and 1.17 million tons and 1.01 and 3.15 million tons, respectively. In the latter period, exports of non-Basmati rice varieties were greater than that of Basmati rice, which reflects the increasing importance of IRRI rice for export. During the crisis period 2007-2008, exports for both varieties decreased, possibly because of the minimum export price policy during this period. However; after the crisis period and the withdrawal of the policy, exports of both varieties increased, with a larger increase seen for non-Basmati rice exports, indicating a greater responsiveness of non-Basmati rice exports to increased prices during the crisis period. As a result of the decrease in prices in 2009-2010, exports of non-Basmati rice decreased again (GoP, 2012; UNFAO, 2010).

A wide range of government policies and regulations influencing the rice markets have been enacted in Pakistan. Still, the interventions in many cases have been temporary, or they have not been implemented to an extent that has had strong effects on economic behavior. For example, there have been restrictions on the movement of rice across regions within Pakistan and bans on the production of certain varieties and sowing in certain areas to reclaim saline lands. Price supports and government procurement programs existed until 2001-2002. After 2002, the government's role has been limited to the occasional and irregular announcement of an indicative support price (Salam, 2009). This essentially is to create a price floor during the post-harvest period when supply is abundant, but it does not replace market-determined prices. The intention is to correct

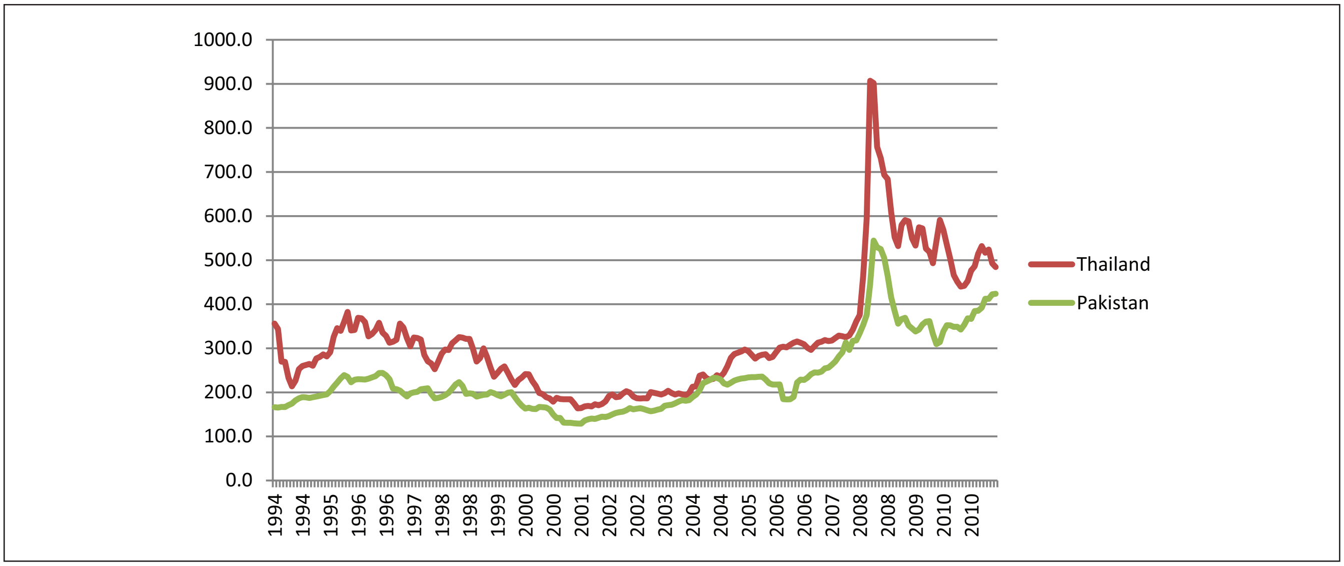

Figure 1. Rice prices in the international and domestic markets of Pakistan (USD per ton).

shortcomings in the marketing system (Anwar, 2004). In 1987-1988, the government allowed the private sector to export rice, which gave rise to the Rice Exporters Association of Pakistan (REAP; 2010), formed in 1988-1989 by private exporters. During the study period, no export taxes were imposed; however, an export subsidy was provided in 2 years, 2002-2003 and 2003-2004 (World Trade Organization [WTO], 2011). However, on account of the high international prices in 2007-2008, the government fixed the minimum export prices in April 2008, but this was abolished by October 2008 (Salam, 2009). Import tariffs on rice were in effect but were reduced from 15% to 10% on an most favored nation (MFN) basis in 1999. Exchange rate policies include a managed float since 1982 and multiple exchange rate regimes in 1998 after the nuclear tests. Since 2000, the current flexible exchange rate system has been in place (Hyder & Mahboob, 2006).

Domestic and International Rice Prices 1994-2011

In this study, we have included prices from six regions in Pakistan, which are Sukhar, Hyderabad, Multan, Rawalpindi, Peshawar, and Hyderabad (see the map in the appendix). Among the selected markets for the present study, Peshawar and Quetta are the provincial capitals of Khyber Pakhtoonkhan and Baluchistan provinces, respectively, while Rawalpindi is the neighbor city of the provincial capital of Punjab, Islamabad. Hyderabad is located close to Karachi, the provincial capital of Sindh and a port city. Sukhar is located in Sindh province close to Hyderabad and also to Multan, close to the border between Sindh and Punjab provinces. Hyderabad and Sukhar are located closer to the major production regions, with populations of about 10.4 and 0.40 million, respectively. Multan is close to Sukhar and has a population of about 1.55 million. Quetta and Peshawar are more remote from the production regions, with populations of about 0.84 and 1.3 million, respectively; however, Peshawar is situated close to the border of Afghanistan, while Quetta is located close to the borders of Iran and Afghanistan. Both countries are among the largest markets for rice exports from Pakistan. Rawalpindi has about 1.83 million inhabitants and lies between Multan and Peshawar but is closer to Peshawar.

The monthly prices of rice in the international market are represented by Thai (FOB) 5% broken long grain white rice. Just like IRRI, this is a coarse grain, and the two are close substitutes. The Thai price and an average price of six domestic regions of Pakistan are plotted in Figure 1. Price fluctuations are evident, along with a declining price trend during the period 1995-2001 followed by rising prices and a sharp increase in price during the international food crisis in 2007-2008. Domestic prices are lower than international prices as transportation costs are not included in domestic prices. Quality differences can be another reason as they are close but not perfect substitutes. Low domestic prices represent an incentive and potential to export. However, our main concern is to study the comovement of prices in the domestic and international markets and to examine whether the changes in the international markets are being transmitted to the domestic markets.

Data and Method

The data for Thai 5% broken white rice in U.S. dollars for the period January 1994 to April 2011 are taken from the World Bank pink sheet (World Bank, 2012a), while the data for prices of IRRI rice in Pakistan's domestic markets are taken from agricultural statistics of Pakistan (GoP, 2012). Domestic prices are converted to U.S. dollars using monthly exchange rates from Oanda (2012). Prices of IRRI rice and Thai 5% are taken to test the market integration between domestic and international markets as both are coarse varieties and are close substitutes. The data for FOB prices of Pakistan, Thailand and Vietnam 25% broken rice are taken from various monthly issues of Rice Market Monitor published by the UNFAO (2013) for the period 2006-2013. These prices are taken to test the integration among the international markets as they are all coarse varieties with 25% broken contents and are close substitute.

Cointegration analysis is a standard approach in studies of market integration. Following the approach of many studies of spatial integration, we apply the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit-root tests to test the stationary of the data. All the price series are found to be non-stationary in levels in log form and stationary in first differences, allowing for the testing of cointegration among the price series. We apply the Johansen methodology (Johansen & Juselius, 1990) estimating the trace and maximum eigenvalues to test for cointegration among the prices series. The Engle and Granger (1987) two-step procedure (hereafter EG) is also used to test for cointegration. As mentioned above, there was a fundamental change in Pakistan's agricultural and trade policy after 2002 when the support policy was terminated and a minimum export price policy was implemented in 2008. Such policy shifts may represent structural breaks in the time series and as such, generate substantial econometric challenges when conducting cointegration analysis. Specifically, a structural break may affect the power of cointegration tests (see, for example, Campos, Ericsson, & Hendry, 1996). A number of econometric approaches have been presented to handle structural breaks in the times series (e.g., Franses, 2001; Johansen, Moscow, & Nilesen, 2000). Instead of applying such rather complicated methods, we have taken a more simplistic approach. Thus, to analyze the effects of the support policy that was ended in 2002 and the export policies that were adopted after 2002, the sample is divided into two sub-periods, before and after 2002. This approach enables us to study directly whether the policy change had an effect on market integration.

Vector error correction models (VECMs) are estimated if the series are cointegrated. The general form of the VECM is as follows:

$$\Delta \mathbf{P}_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta \mathbf{P}_{t-i} + \prod_k \mathbf{P}_{t-k} + \varepsilon_t, \quad (1)$$

where $\mathbf{P}_t$ denotes $n \times 1$ vector of prices; Δ is a first difference operator, such that $\Delta \mathbf{P}_t = \mathbf{P}_t - \mathbf{P}_{t-1}$, Γ_i with $i = 1, \ldots, k-1$ as the short-run coefficient; $\prod = \alpha\beta'$ is a long-run impact matrix summarizing all the long-run information in $\mathbf{P}_t$ process, in which α and β are $n \times r$ matrices of full column rank; the matrix β contains cointegrating vectors and the matrix α is the matrix of the adjustment coefficients to the long-run disequilibrium errors represented by the cointegrating relations; ε_t represents an i.i.d error term; and μ is an intercept.

Previous Studies on Market Integration

There is a large body of literature on commodity market integration, including a number of studies focusing on markets in developing countries. Silvapulle and Jayasuriya (1994) found integration among domestic rice markets in the Philippines, while Dawson and Dey (2002) found highly integrated rice markets in Bangladesh. Van Tilburg, Kuiper, and Swinkels (2008) tested law of one price for potato markets in Bhutan using three auction prices. They found integration during 1996-2000 while market imperfections existed for the period 2002-2005. Munir, Sureshwaran, Selassie, and Nyankori (1997) found market integration among all the selected markets of vegetables in Indonesia. Kaur, Arshad, and Tan (2010) found market integration in the broiler sector in Malaysia although structural rigidities were present. Nga (2009) found integration among 9 out of 34 rice markets in Vietnam, while Ghosh (2010) found integration of grain markets within and across different states in India. Acharya, Ramesh, Birthal, Kumar, and Negi (2012) found integration among most domestic rice and wheat markets in India. Mushtaq and Dawson (2002) applied Johansen's test and the VECM methodology to measure the acreage response of agricultural commodities in Pakistan. Asche, Gjølberg, and Guttormsen (2012) used Johansen's test to test the central market hypothesis in the Sorghum markets of Tanzania. Acharya et al. (2012) applied cointegration and VECM techniques to measure market integration in the rice and wheat markets of India. Silvapulle and Jayasuriya (1994) used Johansen's methodology to test the market integration of rice in the domestic markets of the Philippines. Minot (2011) applied cointegration and error correction techniques to investigate the effects of changes in the world food markets on the staple foods of Sub-Saharan Africa using the small-country assumption. Greb, Jamora, Mengel, von Cramon-Taubadel, and Würriehausen (2012) studied colinks among domestic markets of agricultural commodities in developing countries with those among international markets, using cointegration and error correction techniques.

Among the studies on integration of domestic markets with international markets, Conforti (2004) investigated price transmission for a number of agricultural commodities for 16 countries in Asia, Africa, and Latin America using autoregressive distributed lag models and cointegration tests. He found relatively incomplete transmission in African markets relative to that in Asian and Latin American markets. For Pakistan, he used annual data for some of the major crops and animal products such as meat. He found a long-run relationship between the domestic price and the world reference

Table 1. Unit-Root Tests 1994-2011.

	Log levels				First differences	
	ADF		PP		ADF	PP
Variables	No trend	With trend	No trend	With trend	No trend	No trend
Thailand 5%	−1.15	−1.70	−1.27	−1.98	−7.06	−2.88
Average domestic price	−0.88	−1.71	−0.48	−1.32	−6.65	−9.00
Domestic markets						
Hyderabad	−0.45	−2.82	−0.30	−2.50	−7.39	−10.39
Sukhar	−0.52	−2.35	−0.46	−2.31	−8.08	−13.26
Multan	−0.83	−2.40	−0.77	−2.22	−7.32	−9.97
Rawalpindi	−0.59	−2.27	−0.48	−2.03	−7.31	−9.33
Peshawar	−0.56	−1.73	−0.43	−1.60	−7.10	−10.89
Quetta	−0.31	−1.88	−0.03	−1.43	−7.34	−12.14
Thailand's 25%	−2.02	−2.99	−1.45	−1.91	−5.26	−5.31
Vietnam's 25%	−2.91	−3.31	−2.03	−2.04	−5.32	−5.41
Pakistan's 25%	−2.40	−2.98	−1.69	−1.86	−5.29	−5.29
Critical values (5%)	−2.89	−3.45	−2.89	−3.45	−2.89	−2.89

Note. ADF = Augmented Dickey–Fuller; PP = Phillips–Perron.

price for wheat, rice, maize, and bovine meat; however, cointegration tests did not confirm the results for the latter. He also found a long-run relationship between export prices of Basmati rice and domestic wholesale prices of IRRI rice. Sanogo and Amadou (2010) found that prices of coarse rice in Nepal responded to shocks originating in India. Minot (2011) found long-run relationships with the world food prices for only 13 out of 62 domestic markets in Sub-Saharan Africa. Rice prices are more closely related to international market prices than are maize prices. John (2013) found that Thai rice export price shocks are transmitted into the domestic markets of Thailand, although the causality tests between export and domestic prices were not clear possibly because domestic pricing policies were in place.

Market integration studies were also conducted to analyze the policy effects. Among others, Ghosh (2011) investigated the effects of agricultural policy reforms on spatial market integration of food grain markets in India. He found that policy reforms contributed to improvement of spatial market integration in the post-reform period as segmented or poorly integrated markets in the pre-reforms period were strongly integrated in the post-reform period. Sekhar (2012) found market integration among those agricultural markets of India that did not face restrictions on interstate or interregional trade such as chick-peas and edible oils. He added that rice markets were not integrated at the national level because of restrictions on interstate trade. Chand (2008) found that the price spike in 2007-2008 was not transmitted to the domestic markets of India because of policy intervention by the Indian government (Acharya et al., 2012). Nga (2009), however, found integration among the rice export prices in Vietnam and Thailand, and that removal of export quotas did not have a significant effect on the relationship between prices in these two countries. Dorosh and Rashid (2013) found that before the crisis in 2007, domestic prices in Bangladesh were cointegrated with subsidized import parity prices; however, after mid-2007, prices in Bangladesh increased because of the restrictive export policies of India, which is one of the biggest import markets for Bangladesh. John (2013) concluded that Thailand's domestic price policies are not creating large distorting effects on world rice markets.

Econometric Results

The results for the ADF and PP unit-root tests are presented in Table 1. The hypothesis that the log prices contain a unit root could not be rejected at the 5% level of significance, indicating that all the prices are non-stationary except the Vietnam 25% price, which is stationary at the 5% level of significance according to ADF test, but non-stationary according to the PP test. The ADF test statistic of −2.91 is very close to the 5% critical value of −2.89. However, taking the first differences of the logs of prices, the unit-root hypothesis is clearly rejected. These tests were also applied by including a trend term, but the stationarity results remain unchanged. So, all the prices series are I (1), permitting an analysis of cointegration among the prices obtained in the different markets.

In this study, pairwise market integration among Pakistan's domestic markets is tested using the Johansen and EG methodologies. Lag selection was made using the Akaike information criterion (AIC), Schwarz Bayesian information criteria (SBIC), and/or Hannen–Quim information criteria (HQIC) selection criteria for Johansen tests while four lags were selected for EG tests. Using Johansen's

Table 2. Johansen's Test for Cointegration 1994-2011.

Markets	Null	Alternative	Trace	5% CV	Maximum eigenvalues	5% CV
All International Rice Research Institute rice markets	$r = 0$	$r \geq 1$	183.42	39.37	74.95	94.15
	$r \leq 1$	$r \geq 2$	108.47	33.46	40.13	68.52
	$r \leq 2$	$r \geq 3$	68.35	27.07	33.24	47.21
	$r \leq 3$	$r \geq 4$	35.10	20.97	25.68	29.68
	$r \leq 4$	$r \geq 5$	9.42	14.07	9.29	15.41
	$r \leq 5$	$r \geq 6$	0.13	3.76	0.13	3.76

Markets	Null	Alternative	Trace	Maximum eigenvalues
Hyderabad–Sukhar	$r = 0$	$r \geq 1$	20.70	20.68
	$r \leq 1$	$r \geq 2$	0.04	0.04
Hyderabad–Multan	$r = 0$	$r \geq 1$	16.60	16.44
	$r \leq 1$	$r \geq 2$	0.16	0.16
Hyderabad–Rawalpindi	$r = 0$	$r \geq 1$	15.51	15.35
	$r \leq 1$	$r \geq 2$	0.16	0.16
Hyderabad–Peshawar	$r = 0$	$r \geq 1$	**11.62**	**11.53**
	$r \leq 1$	$r \geq 2$	**0.09**	**0.09**
Hyderabad–Quetta	$r = 0$	$r \geq 1$	**13.98**	**13.96**
	$r \leq 1$	$r \geq 2$	**0.10**	**0.01**
Sukhar–Multan	$r = 0$	$r \geq 1$	31.72	31.21
	$r \leq 1$	$r \geq 2$	0.50	0.50
Sukhar–Rawalpindi	$r = 0$	$r \geq 1$	40.02	39.77
	$r \leq 1$	$r \geq 2$	0.25	0.25
Sukhar–Peshawar	$r = 0$	$r \geq 1$	23.87	23.61
	$r \leq 1$	$r \geq 2$	0.26	0.26
Sukhar–Quetta	$r = 0$	$r \geq 1$	38.79	38.75
	$r \leq 1$	$r \geq 2$	0.04	0.04
Multan–Rawalpindi	$r = 0$	$r \geq 1$	37.49	36.91
	$r \leq 1$	$r \geq 2$	0.57	0.57
Multan–Peshawar	$r = 0$	$r \geq 1$	35.05	34.55
	$r \leq 1$	$r \geq 2$	0.49	0.49
Multan–Quetta	$r = 0$	$r \geq 1$	61.64	61.48
	$r \leq 1$	$r \geq 2$	0.15	0.15
Rawalpindi–Peshawar	$r = 0$	$r \geq 1$	35.77	35.38
	$r \leq 1$	$r \geq 2$	0.38	0.38
Rawalpindi–Quetta	$r = 0$	$r \geq 1$	48.53	48.36
	$r \leq 1$	$r \geq 2$	0.17	0.17
Peshawar–Quetta	$r = 0$	$r \geq 1$	44.63	44.45
	$r \leq 1$	$r \geq 2$	0.18	0.18
Critical values (5%)	$r = 0$	$r \geq 1$	15.41	14.07
	$r \leq 1$	$r \geq 2$	3.76	3.76

Note. CV = Critical Values

method (Table 2), we find all the pairs to be cointegrated except for Hyderabad–Peshawar and Hyderabad–Quetta. Applying the EG test (Table 3), we find that the Hyderabad–Peshawar, Hyderabad–Rawalpindi, and Hyderabad–Multan pairs are not cointegrated (indicated with bold formatting). No cointegration indicates that price signals are not transmitted efficiently from one market to another, possibly resulting in non-optimal decisions among producers, consumers, and inventory holders. Moreover, marketing margins are likely to be higher than in other markets as the absence of cointegration can be exploited by traders. The possible absence of cointegration and inefficient flow of information between Hyderabad and Peshawar/Quetta may reflect the distance between these markets, situated in three different provinces and having the greatest distance among the sample markets. The result may also reflect low levels of trade and poor infrastructure. Government investment, particularly in infrastructure and transportation, in markets that are not integrated might help to integrate these markets.

The results from our Johansen cointegration and EG tests are presented in Tables 4 and 5, respectively. The results

Table 3. Stationarity of Residuals From Pairwise Regressions 1994-2011 (Engle–Granger Tests).

Market pairs	ADF	
Regression residuals	No trend	Lags
Hyderabad–Sukhar	−3.251	4
Hyderabad–Multan	**−3.018**	4
Hyderabad–Rawalpindi	**−2.610**	4
Hyderabad–Peshawar	**−2.777**	4
Quetta–Hyderabad	−3.468	4
Sukhar–Multan	−4.088	4
Sukhar–Rawalpindi	−4.349	4
Sukhar–Peshawar	−3.402	4
Quetta–Sukhar	−3.989	4
Multan–Rawalpindi	−5.353	4
Multan–Peshawar	−5.277	4
Multan–Quetta	−5.141	4
Rawalpindi–Peshawar	−4.837	4
Quetta–Rawalpindi	−4.321	4
Quetta–Peshawar	−3.760	4
Engle and Yoo 5% critical values	−3.25	

Note. ADF = Augmented Dickey–Fuller.

Table 4. Johansen's Cointegration Tests for Pakistan's Rice Markets With the International Market 1994-2011.

Markets	Null	Alternative	Trace	Maximum eigenvalues
Average domestic price—Thailand	$r = 0$	$r \geq 1$	29.91	14.07
	$r \leq 1$	$r \geq 2$	0.92	3.76
Hyderabad–Thailand	$r = 0$	$r \geq 1$	19.69	19.04
	$r \leq 1$	$r \geq 2$	0.65	0.65
Sukhar–Thailand	$r = 0$	$r \geq 1$	23.74	22.49
	$r \leq 1$	$r \geq 2$	1.25	1.25
Multan–Thailand	$r = 0$	$r \geq 1$	34.68	32.27
	$r \leq 1$	$r \geq 2$	2.41	2.41
Rawalpindi–Thailand	$r = 0$	$r \geq 1$	36.90	35.20
	$r \leq 1$	$r \geq 2$	1.70	1.70
Peshawar–Thailand	$r = 0$	$r \geq 1$	36.27	35.09
	$r \leq 1$	$r \geq 2$	1.17	1.17
Quetta–Thailand	$r = 0$	$r \geq 1$	35.39	35.38
	$r \leq 1$	$r \geq 2$	0.02	0.02
Viet–Thai 25%	$r = 0$	$r \geq 1$	17.98	15.88
	$r \leq 1$	$r \geq 2$	2.09	2.09
Pak–Thai 25%	$r = 0$	$r \geq 1$	15.92	11.46
	$r \leq 1$	$r \geq 2$	4.45	4.45
Pak–Viet 25%	$r = 0$	$r \geq 1$	29.55	23.99
	$r \leq 1$	$r \geq 2$	5.56	5.56
Critical values 5%	$r = 0$	$r \geq 1$	15.41	14.07
	$r \leq 1$	$r \geq 2$	3.76	3.76

indicate that a long-run cointegration relationship exists between the prices. The trace and maximum eigenvalue statistics are greater than their respective critical values, suggesting

Table 5. Stationarity of Residuals for Pakistan and International Markets (Engle–Granger Tests) 1994-2011.

Market pairs		
Regression residuals	ADF	Lags
Average domestic price	−3.638	4
Hyderabad–Thailand	**−2.778**	4
Sukhar–Thailand	**−2.734**	4
Multan–Thailand	−3.765	4
Rawalpindi–Thailand	−3.523	4
Peshawar–Thailand	−4.068	4
Quetta–Thailand	−3.638	4
Thai–Viet 25	**−2.522**	4
Pak–Thai 25	**−2.634**	4
Pak–Viet 25	−4.564	4
Engle and Yoo 5% critical values	−3.25	

Note. Bold values represents the market pairs which are not integrated. ADF = Augmented Dickey–Fuller.

that all six domestic markets are integrated with the international market and that there is one cointegrating vector in each pair of domestic markets and the international market. The results also show that the average prices of rice in the domestic markets of Pakistan and the price of Thai 5% broken rice are also cointegrated. The ADF results for the EG tests show that all domestic prices including their average are integrated with the Thai 5% prices except for prices in Hyderabad and Sukhar markets.

The trace and maximum eigenvalue statistics for Thai and Viet 25% broken rice show that these export prices are integrated, while the results of the EG test indicate that these markets are not integrated. Both the Johansen and EG tests find that Pak and Viet 25% export prices are cointegrated, whereas results for Pak and Thai 25% are mixed. According to the trace statistics, these markets are integrated, whereas the maximum eigenvalue statistics and EG tests show that they are not integrated.

As described in "An Overview of the Rice Sector in Pakistan" section of this article, there was a policy change in 2001-2002, when the support price policy was terminated. Moreover, after 2002, export subsidies were granted to rice exporters for the 2 years 2002-2003 and 2003-2004, and a minimum export price policy was adopted on account of the price spike during the so-called food crisis in 2007-2008. After 2002, the government's role was limited to the occasional and irregular announcement of an indicative support price (Salam, 2009). The data set is divided into two parts—that is, before and after 2002. ADF and PP unit-root tests are performed on both data sets, and the results are presented in Tables 6 and 7. The results indicate that both the series are non-stationary at log levels and stationary after taking first difference of the log series suggesting that order of integration is one. Two exceptions are Hyderabad, which is stationary at 5% level during 2003-2011, and Peshawar, which is stationary at 10% in the period 1994-2002.

Table 6. Unit-Root Tests 1994-2002.

	Log levels				First differences	
	ADF		PP		ADF	PP
Variables	No trend	With trend	No trend	With trend	No trend	No trend
Thailand 5%	−0.83	−2.32	−1.38	−2.06	−8.03	−7.87
Average domestic price	−1.32	−2.73	−1.12	−2.36	−6.29	−6.30
Domestic markets						
Hyderabad	−1.83	−2.86	−1.58	−2.34	−8.40	−8.52
Sukhar	−1.62	−2.35	−1.61	−2.21	−7.65	−7.47
Multan	−1.92	−3.00	−1.81	−2.71	−6.29	−6.16
Rawalpindi	−1.50	−2.62	−1.45	−2.45	−7.16	−7.01
Peshawar	−1.39	−3.30	−1.23	−2.78	−7.62	−7.59
Quetta	−1.28	−2.45	−1.19	−2.29	−6.62	−6.49
Critical values (5%)	−2.890	−3.451	−2.89	−3.45	−2.89	−2.89

Note. ADF = Augmented Dickey–Fuller; PP = Phillips–Perron.

Table 7. Unit-Root Tests 2003-2011.

	Log levels				First differences	
	ADF		PP		ADF	PP
Variables	No trend	With trend	No trend	With trend	No trend	No trend
Thailand 5%	−1.57	−2.33	−1.43	−2.03	−5.96	−5.91
Average domestic price	−1.48	−2.63	−1.29	−2.07	−6.37	−6.42
Domestic markets						
Hyderabad	−2.12	−3.77	−1.95	−3.15	−6.77	−6.73
Sukhar	−1.62	−2.69	−1.63	−2.64	−9.67	−9.67
Multan	−1.67	−2.70	−1.61	−2.43	−7.07	−7.04
Rawalpindi	−1.67	−2.80	−1.54	−2.46	−6.03	−6.01
Peshawar	−1.37	−1.92	−1.32	−1.84	−7.68	−7.62
Quetta	−1.00	−2.55	−0.89	−2.34	−9.75	−9.74
Critical values (5%)	−2.89	−3.45	−2.891	−3.451	−2.89	−2.89

Note. ADF = Augmented Dickey–Fuller; PP = Phillips–Perron.

The Johansen and EG tests were used to test for cointegration among pairs of domestic markets as well as the international market. The ADF stationarity test results (Table 8) for the EG test reveal that 10 market pairs were not integrated until 2002, whereas the number of non-integrated market pairs falls from 10 to 8 after 2002. This indicates that the degree of cointegration among the domestic markets increased after the termination of the support price policy. However, before 2002, this policy did not seem to influence the degree of cointegration of Pakistan's domestic markets with the international market as almost all the markets were integrated with the international market. The results suggest a positive influence of the policy change on the functioning and degree of cointegration within the domestic markets, which supports the cessation of the costly support price policy and government procurement. Mushtaq and Dawson (2002) recommended ending the support price policy for rice in Pakistan.

Both the Johansen and EG test results show that all the domestic rice markets were integrated with the international market before 2002 except for Hyderabad, which was not integrated according to Johansen's test but integrated according to the EG test results. Using the average domestic price as a proxy for Pakistan's rice market, we also find Pakistan to be integrated with the international market before 2002. However, both tests show that the degree of market integration with the international market decreased after 2002 as Sukhar and Multan were no longer integrated according to the Johansen test results (Table 9), whereas all the markets were no longer integrated according to EG results (Table 10). Moreover, both of the test results show that average domestic prices were not cointegrated with the international reference price after 2002. The export subsidy policies adopted by Pakistan during the period 2002-2004 and the minimum export price policy in 2008 may have caused this decrease in the degree of integration.

Table 8. Stationarity of Residuals From Pairwise Regressions (Two-Step Procedures).

Market pairs	ADF	ADF	
Regression residuals	1994-2002	2003-2011	Lags
Hyderabad–Sukhar	**−2.497**	**−2.652**	4
Hyderabad–Multan	**−2.332**	**−2.570**	4
Hyderabad–Rawalpindi	**−2.220**	**−1.858**	4
Hyderabad–Peshawar	**−2.048**	**−2.478**	4
Quetta–Hyderabad	**−2.437**	−3.669	4
Sukhar–Multan	**−2.836**	−4.102	4
Sukhar–Rawalpindi	**−2.893**	−3.700	4
Sukhar–Peshawar	**−2.951**	**−2.965**	4
Quetta–Sukhar	−3.319	**−2.678**	4
Multan–Rawalpindi	−4.972	−3.356	4
Multan–Peshawar	−3.731	−4.285	4
Multan–Quetta	−4.490	−3.337	4
Rawalpindi–Peshawar	**−2.898**	−4.418	4
Quetta–Rawalpindi	−4.145	**−2.762**	4
Quetta–Peshawar	**−2.970**	**−2.384**	4
Engle and Yoo 5% critical values	−3.17	−3.17	

Note. Bold values represents the market pairs which are not integrated. ADF = Augmented Dickey–Fuller.

The pairwise VECM estimates using the maximum likelihood method for those domestic markets found to be cointegrated are reported in Table 11. Lag selection was made using the AIC, SBIC, and/or HQIC selection criteria, which suggested the lag order of two. Langrangian–Multiplier (LM) test was applied to test autocorrelation between the VECM residuals. The results accept the hypothesis of no autocorrelation at 5% level of significance in most of the market pairs except Quetta–Rawalpindi, Quetta–Sukhar, and Quetta–Peshawar; however, autocorrelation does not exist at Lag 1. As the estimations for all other market pairs are conducted at Lag Level 2, we did the same for these market pairs for getting short-run elasticities and better comparisons. However, there is no change in the level of significance of the coefficients, while their magnitude varies a little. The coefficients for the long-run relationships are statistically significant and negative at the 1% level of significance in all pairs. The long-run elasticity of price transmission ranges from 0.89 to 1.0 indicating a high degree of transmission of price changes from one market to the other in the long run. The Johansen test results for cointegration show that a long-run relationship exists among these markets. However, the degree and statistical significance of the coefficients on the speed of adjustment vary across the pairs. For most of the pairs, the coefficients on the speed of adjustment are statistically significant at the 1% or 5% level of significance, except for Multan–Quetta, which is significant only at the 10% level of significance. These coefficients have the expected signs, indicating that prices converge. However, there are two exceptions, Rawalpindi–Quetta and Peshawar–Quetta, whose coefficients are not statistically significant. In contrast, the coefficients of Quetta–Rawalpindi and Quetta–Peshawar are statistically significant, implying that prices in the Quetta markets adjust to correct any disequilibrium between these pairs. The values of the coefficients of short-run adjustment are all small, varying from 0.02 to 0.22. The pairs including Hyderabad have the lowest speed of adjustment. The pairs including Rawalpindi, the neighboring city of Pakistan's capital Islamabad, move quickly toward equilibrium with a speed of adjustment from 11% to 22%, except for Rawalpindi–Quetta, which has an insignificant coefficient as described earlier. A possible reason is the large distance between the two markets, resulting in low volumes of trade. The actual data on trade between these markets are not available; however, it can be approximated on the basis of the distance between the cities and from the location of the production regions. For instance, Quetta and Rawalpindi are both non/very small producers and very far from each other, being situated on two different sides of the producing regions and in two different provinces.

In general, the process of adjustment toward long-run equilibrium appears to be slow. The estimated correction parameters are in the range 0.03 to 0.22 across the different market pairs, implying that 3% to 22% of any divergence from long-run equilibrium is corrected monthly. Possible reasons for this slow adjustment are the low level of domestic consumption, low volume of trade in distant market pairs, poor infrastructure, and market power of traders. The coefficients on the short-run elasticity of price transmission are statistically significant and have the expected signs in many cases, suggesting that price changes in recent months significantly affect current and future changes in the prices among these market pairs. These results are helpful for forming expectations of future prices and accordingly, decisions regarding storage and resource allocation. However, there are market pairs where the short-run price transmission elasticity coefficients are not significant, suggesting that past changes in prices are not transmitted in the short run, although there exist significant long-run equilibrium relationships. This might be due to the direction of causality, distance, and infrastructure between them resulting in weak market integration or a low speed of adjustment.

The VECM's results for the Pakistan's domestic and international markets are reported in Table 12. Lag selection was made using the AIC, SBIC, and/or HQIC selection criteria, which suggested the lag order of two. LM test was applied to test autocorrelation between the VECM residuals. The results accept the hypothesis of no autocorrelation at 5% level of significance. The coefficients on the speed of adjustment in domestic as well as international markets are statistically significant at 1% or 5%

Table 9. Johansen's Test for Cointegration.

Markets	Null	Alternative	1994-2002 Trace	1994-2002 Maximum eigenvalues	2003-2011 Trace	2003-2011 Maximum eigenvalues
Hyderabad–Thailand FOB	$r = 0$	$r \geq 1$	**14.753**	**13.443**	20.208	16.925
	$r \leq 1$	$r \geq 2$	**1.309**	**1.309**	3.282	3.282
Sukhar–Thailand FOB	$r = 0$	$r \geq 1$	25.592	24.362	**12.629**	**9.094**
	$r \leq 1$	$r \geq 2$	1.229	1.229	**3.534**	**3.534**
Multan–Thailand FOB	$r = 0$	$r \geq 1$	31.605	29.851	**14.941**	**11.339**
	$r \leq 1$	$r \geq 2$	1.754	1.754	**3.602**	**3.602**
Rawalpindi–Thailand FOB	$r = 0$	$r \geq 1$	32.705	31.264	18.235	14.701
	$r \leq 1$	$r \geq 2$	1.440	1.440	3.535	3.535
Peshawar–Thailand FOB	$r = 0$	$r \geq 1$	28.04	27.24	16.209	13.824
	$r \leq 1$	$r \geq 2$	0.804	0.804	2.385	2.385
Quetta–Thailand FOB	$r = 0$	$r \geq 1$	35.350	34.414	22.949	21.682
	$r \leq 1$	$r \geq 2$	0.936	0.936	1.267	1.266
Average–Thailand FOB	$r = 0$	$r \geq 1$	36.030	35.065	**13.643**	**11.319**
	$r \leq 1$	$r \geq 2$	0.965	0.965	**2.324**	**2.324**
Critical values	$r = 0$	$r \geq 1$	15.41	14.07	15.41	14.07
	$r \leq 1$	$r \geq 2$	3.76	3.76	3.76	3.76

Note. Bold values represents the market pairs which are not integrated.

Table 10. Engle–Granger Test Results for Domestic and International Market Cointegration Before and After 2002.

Market pairs	ADF	ADF	
Regression residuals	1994-2002	2003-2011	Lags
Hyderabad–Thailand FOB	−3.827	**−2.906**	4
Sukhar–Thailand FOB	−3.558	**−1.691**	4
Multan–Thailand FOB	−4.304	**−2.423**	4
Rawalpindi–Thailand FOB	−3.720	**−2.998**	4
Peshawar–Thailand FOB	−3.995	**−2.835**	4
Quetta–Thailand FOB	−3.467	**−2.637**	4
Average–Thailand FOB	−4.428	**−2.339**	4
Engle and Yoo 5% critical values	−3.17	−3.17	

Note. Bold values represents the market pairs which are not integrated. ADF = Augmented Dickey–Fuller.

level of significance except for Peshawar. This suggests that both the prices adjust to deviations from the long-run equilibrium; however, coefficient values are very small ranging from 0.03 to 0.11, which suggest that process of adjustment is very slow. About 3% to 11% of deviation from the long-run equilibrium is adjusted every month. The possible reasons can be the infrastructure deficiencies, slow transportation, and trade rigidities. Our objective in this article is to examine the price transmission from the international markets to the domestic markets of Pakistan. Hence, interpretation of the results focuses on the results of domestic market equations in the VECM.

The VECM estimates for each of the individual domestic markets paired with the international market show that the coefficients of the speed of adjustment in all markets are statistically significant at the 1% level of significance, except for the Hyderabad market, which is significant at the 5% level of significance. This coefficient is not significant for Peshawar. This implies that prices in all individual markets except Peshawar move toward a long-run equilibrium with the international market. The coefficient value in Rawalpindi, Multan, and Quetta markets is about 0.10. The values of these coefficients for Sukhar and Hyderabad, the closest markets geographically, are 0.07 and 0.02, respectively. The coefficient for the Hyderabad market is quite low despite the fact that the Hyderabad is not far away from Karachi from where it is easy to ship rice to the international markets. This reflects that direct trade from Sukhar to Karachi is taking place. Sukhar is located relatively closer to the production areas, and it makes a little difference to travel to Karachi or Hyderabad. The coefficients on the long-run equilibrium in all the markets are statistically significant at the 1% level of significance. The coefficient values ranges from 0.68 to 0.98, showing that in the long run, about 68% to 98% of changes in the international market are transmitted to the domestic markets of Pakistan.

The short-run elasticity of price transmission with respect to own lagged differenced market price and lagged differenced international price presents a mixed picture. All the short-run elasticity coefficients are statistically significant at the 1% or 5% level of significance except for Sukhar and Quetta. In Sukhar, its own price short-run coefficient is not significant, whereas in Quetta, short-run coefficient with respect to world's price is not significant. The values on these coefficients range from 0.21 to 0.32. The Hyderabad market captures more of the effect of past changes in its own price, 32%, compared with the international price. Only 3% of changes in the international market

Table 11. VECM Estimates for the Domestic (All) and International Markets During 1994-2011.

	Dependent variable: Prices in the domestic markets				
Independent variables	HYD–RWP	RWP–HYD	HYD–MTN	MTN–HYD	HYD–SKR
Speed of adjustment	−0.06[a]	0.05[b]	−0.05[a]	0.06[b]	−0.06[a]
Long-run coefficient	−0.89[a]	−0.89[a]	−0.89[a]	−0.89[a]	−0.89[a]
Own lagged differenced price	0.24[a]	−0.08	0.25[a]	−0.21[a]	0.3[a]
Other market's lagged diff. price	0.12[a]	0.45[a]	0.11[a]	0.4[a]	0.02
Constant	0.005[b]	0.006[c]	0.006[a]	0.007[c]	0.008[a]
LM test	0.11		0.45		0.21
Independent variables	SKR–HYD	RWP–MTN	MTN–RWP	RWP–SKR	SKR–RWP
Speed of adjustment	0.1[a]	−0.11[a]	0.22[a]	−0.11[a]	0.19[b]
Long-run coefficient	−0.89[a]	−1.00[a]	−1.00[a]	−1.00[a]	−1.00[a]
Own lagged differenced price	−0.05	0.19[a]	−0.10	0.38[a]	−0.11
Other market's lagged diff. price	0.13[c]	0.34[a]	0.48[a]	0.10[c]	0.18[a]
Constant	0.004	0.005[b]	0.002	0.007[b]	0.004
LM test			0.81	0.32	
	RWP–PSW	PSW–RWP	QTA–RWP	RWP–QTA	MTN–SKR
Speed of adjustment	−0.13[a]	0.12[a]	0.19[a]	−0.02	−0.10[a]
Long-run coefficient	−0.98[a]	−0.98[a]	0.97[a]	−1.00[a]	−1.00[a]
Own lagged differenced price	0.34[a]	0.08	0.04	0.44[a]	0.37[a]
Other market's lagged diff. price	0.35[a]	0.33[a]	0.04	−0.08	0.01
Constant	0.004	0.005	0.001	0.007[b]	0.007[c]
LM test		0.91	15.11[a]		
Independent Variables	SKR–MTN	MTN–PSW	PSW–MTN	QTA–MTN	MTN–QTA
Speed of adjustment	0.17[a]	−0.17[a]	0.09[a]	0.19[a]	−0.06[c]
Long-run coefficient	−1.00[a]	−0.98[a]	0.02[a]	−1.00[a]	−1.00[a]
Own lagged differenced price	0.19[b]	0.33[a]	0.26	−0.08[c]	0.42[a]
Other market's lagged diff. price	0.03	0.22[a]	0.01[a]	0.08	−0.13
Constant	0.004	0.004	0.005	0.003	0.009[b]
LM test	0.71		0.53		7.72[c]
Independent Variables	SKR–PSW	PSW–SKR	SKR–QTA	QTA–SKR	PSW–QTA
Speed of adjustment	−0.16[a]	0.07[a]	−0.06	0.14[a]	−0.02
Long-run coefficient	−0.97[a]	−0.97[b]	−0.99[a]	−0.99[a]	−1.00[a]
Own lagged differenced price	0.06	0.02	0.11	−0.06	0.28[a]
Other market's lagged diff. price	0.30[a]	0.26[a]	0.01	0.13[b]	−0.01
Constant	0.003	0.007[b]	0.010[b]	0.004	0.008[b]
LM test	0.65		11.66[a]		16.86[a]
Independent variables	QTA–PSW				
Speed of adjustment	0.17[a]				
Long-run coefficient	−1.00[a]				
Own lagged differenced price	−0.18[a]				
Other market's lagged diff. price	0.17[a]				
Constant	0.001				

Note. VECM = vector error correction model; HYD = Hyderabad; RWP = Rawalpindi; MTN = Multan; SKR = Sukhar; PSW = Peshawar; QTA= Quetta; LM = Langrangian–Multiplier.
[a,b,c]Statistically significant at the 1%, 5%, and 10% levels, respectively.

price are transmitted within 2 months. The Sukhar market price does not respond significantly to past changes in its own price; however, about 28% of changes in the international price are transmitted within 1 month. In Rawalpindi,

Table 12. VECM Estimates for the Domestic (All) and International Markets.

	Dependent variable: Prices in the respective markets				
Independent variables	HYD–Thai	Thai–HYD	SKR–Thai	Thai–SKR	MTN–Thai
Speed of adjustment	−0.03[c]	0.10[a]	−0.07[b]	0.10[a]	−0.10[a]
Long-run coefficient	−0.68[a]	−0.68[a]	−0.89[a]	−0.89[a]	−0.90[a]
Domestic market's differenced price	0.31[a]	−0.10	0.04	−0.12[b]	−0.28[a]
International market's lagged diff. price	0.03[a]	0.39[a]	0.32[a]	0.43[a]	0.34[a]
Constant	0.002	0.0007	0.003	0.002	0.002
LM test	0.94		0.75		7.98[c]
Independent variables	Thai–MTN	RWP–Thai	Thai–RWP	PSW–Thai	Thai–PSW
Speed of adjustment	0.10[a]	−0.11[a]	0.12[a]	−0.04	0.17[a]
Long-run coefficient	−0.90[a]	−0.90[a]	−0.91[a]	−0.98[a]	−0.98[a]
Domestic market's differenced price	−0.09	0.19[a]	0.16[a]	0.19[a]	0.07
International market's lagged diff. price	0.42[a]	0.34[a]	0.44[a]	0.18[a]	−0.42
Constant	0.002	0.005[b]	0.001	0.003	0.0009
LM test		0.43		8.13[c]	
	QTA–Thai	Thai–QTA			
Speed of adjustment	0.09[a]	0.13[a]			
Long-run coefficient	−0.89[a]	−0.89[a]			
Domestic market's differenced price	−0.15[b]	−0.06			
International market's lagged diff. price	0.04	0.44[a]			
Constant	0.003	0.002			
LM test	7.9[c]				

Note. VECM = vector error correction model; HYD = Hyderabad; RWP = Rawalpindi; MTN = Multan; SKR = Sukhar; PSW = Peshawar; QTA= Quetta; LM = Langrangian–Multiplier.
[a,b,c]Statistically significant at the 1%, 5%, and 10% levels, respectively.

42% of past price changes are transmitted each month compared with 33% of changes in the international market over a month. The values for the Peshawar market are 19% and 18% in 1 month, respectively. The coefficients on the short-run elasticities with respect to the international price in the Quetta market are not significant, whereas with respect to its own market, it is significant. This shows a low responsiveness of the Quetta market to the international market, although it is integrated with the international market, and its long-run coefficient is statistically significant. Low responsiveness may be due to its geographical location, which is far from most of the other major markets, small size of the market, and poor law and order condition. Greb et al. (2012) found that rice market pairs are less cointegrated than maize markets. They also found that domestic prices adjust to international prices for most agricultural commodities except rice. Contrary to Greb et al. (2012), we find that Pakistan's domestic prices for rice adjust to the international market; however, the level of the adjustment is low.

The above results can be helpful in decision making regarding allocation of resources by producers and inventory holders as well as consumers. Producers and traders can form forecasts of future price changes based on changes in prices in the current and recent past period, and can make their production and storage decisions accordingly. Producers can allocate more resources to increase production if they expect increases in prices, and vice versa, based on the long-run price adjustment coefficient. Inventory holders can form expectations based on the short-run coefficients. They will store if they expect prices to increase in the coming months, and vice versa. These production and storage decisions can affect food security.

Summary and Conclusion

In this study, we have reported econometric results on whether Pakistan's rice markets are integrated domestically and with international markets, focusing on cointegration and the speed of price adjustments. We investigate the effects of the change in policy that took place in 2002; when Pakistan terminated its support price policy and subsequently introduced export policies, export subsidy, and minimum export price policy.

The results from the EG and Johansen tests strongly indicate that all the domestic markets are integrated, possibly excepting Hyderabad–Peshawar, Hyderabad–Rawalpindi, Hyderabad–Multan, and Hyderabad–Quetta. The VECM estimates of the domestic markets reveal that prices converge in the long run; however, the speed of adjustment toward long-run equilibrium is generally low. The adjustment coefficients vary from 0.02 to 0.22 across various pairs of markets, indicating that about 2% to 22% of the divergence from the long-run equilibrium is being corrected monthly. The long-run coefficient varies from 0.89 to 1, revealing that about 90% to 100% of price changes are transmitted across different pairs of the markets in the long run. The ending of the support price policy seems to have resulted in an improvement in the integration of domestic markets as the number of non-integrated market pairs decreased after 2002.

All the domestic markets in Pakistan appear to be integrated with the international market possibly excepting Hyderabad and Sukhar, although the speed of adjustment is rather slow. The estimated coefficients of adjustments indicate that the domestic markets tend to converge with the international market in the long run, and about 3% to 11% of the divergence from long-run equilibrium due to shocks in the international market is corrected within a month. Slow adjustment may be due to the existence of infrastructure deficiencies, slow transportation, and trade rigidities. Government should invest on infrastructure to improve the extend of market integration and speed up the process of adjustment toward long-run equilibrium particularly in the province of Sindh, which is the main production region and possesses low quality of infrastructure with greater room for infrastructure development. Government should act as watch dog and keep an eye on the marketing system particularly on the role of market intermediaries to avoid any malpractices that can affect the smooth functioning and integration of markets, which can convey the wrong signals to producers and can result in inefficient allocation of resources. The long-run elasticity of price transmission ranges from 0.68 to 0.98 across markets, suggesting that 68% to 98% of changes in the international price are transmitted to domestic prices in the long run. Among the export markets for rice, Pakistan's rice markets seem to be integrated with the markets of Thailand and Vietnam.

The cointegration and VECM results suggest that while domestic markets are integrated with, and responsive to, changes in the international market and domestic markets, responsiveness to own (local) shocks is higher although exceptions exist. Producers and traders can form expectations of future changes in prices based on changes in prices in the current and last period, and can make their production and storage decisions accordingly.

Support price policy reforms have improved market integration within Pakistan; however, they do not seem to have affected the integration of Pakistan with the international market, while export policies have reduced the extent of market integration of Pakistan with the international market. It is, therefore, reasonable to conclude that reducing government intervention in price determination would increase international market integration further.

Appendix

Map of Pakistan showing provinces and their capitals and selected markets in this study.

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Notes

1. Since 2011, the Thai rice price has no longer been used as an international reference price. After being elected in 2011, Prime Minister Yingluck Shinawatra introduced substantial subsidies to Thai rice farmers, causing Thai rice prices to increase substantially above international prices.
2. Some further details can be found in Ahmad and Garcia (2012).
3. International Rice Research Institute (IRRI6) and IRRI9 coarse rice varieties were developed at the IRRI in the Philippines. IRRI9 was developed by crossing the IRRI6 and Basmati rice varieties.

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