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ABSTRACT

There is no consensus on what defines a reference for the world rice price. A review on rice as a differentiated commodity shed two important insights. First, it confirms that few studies have considered segmentation of rice in their price analysis. Second, Thai 5% brokens has often been considered the world reference price for rice but no empirical exercise has been carried out to validate this. This study analyzes the extent of market integration in the international rice market by generating empirical evidence on the cointegration of different export prices. We start our analysis with the assumption that rice is not a homogeneous good. In this context, we establish clusters by rice quality and determine which export markets best represent the world rice price within and across clusters. The study uses 19 monthly average export rice price quotations from January 2000 to July 2012 extracted from the FAO Global Information and Early Warning System food price database and from the Thai Rice Exporters Association. We also include FAO Export Price indices for high and low quality indica to assess their performance with other export prices. Our study contributes to the limited discussion on rice as a heterogeneous commodity.

We validate Thai 5% brokens as the benchmark price for rice by examining its bivariate relationships with other export prices. We employ Johansen maximum likelihood procedure to confirm the long-run equilibrium relations and cointegration of price series. Then, we extend the error correction model to a multivariate cointegration analysis by cluster. We test for the Law of One Price, long run exclusion, and weak exogeneity to assess the dynamics of price transmission and determine how prices are related with one another. We build on this information and our knowledge of the rice market system to answer the question – What is the world rice price?

We find evidence that the rice market is highly segmented. This suggests that there is no single answer to our research question. While we find that Thai 5% brokens is cointegrated with many other export prices and contributes strongly in defining long run equilibrium relations, there are several international rice prices that could be used as benchmarks. The results imply that failure to find cointegrating relations from world to domestic rice markets can be a result of failure to effectively define the appropriate international reference price. In price transmission analysis, we find that it is imperative to examine the types of rice and to discuss the relevance of specific markets to the benchmark price based on understanding of rice trade structure. This study affirms the importance of having up-to-date and reliable sources of rice prices both in the export and domestic markets, accounting for differences in quality.

JEL: C32, Q11, Q17, Q18
Keywords: rice, price transmission, cointegration, world price

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Contents

1. INTRODUCTION

The world price of a commodity typically refers to the prevailing spot price at a certain market where significant amount of trade is taking place (Bukenya & Labys, 2005). However, there is no consensus on what defines a reference for the world rice price. Unlike other cereals such as wheat and corn, there is no “market-determined average world price” at any given point in time (Barker, Herdt, & Rose, 1985). Nevertheless, the review of literature gave some indications on what researchers consider as the benchmark for the world price. In a World Bank (WB) study (Greb, Jamora, Mengel, von Cramon-Taubadel, & Würriehausen, 2012) looking at the error correction mechanism aspect of spatial price transmission (PT) from world to domestic cereal markets, Thailand export prices dominated in 155 out of 215 rice market pairs and Thai 5% brokens was frequently cited as the world reference price (55%). However, in the construction of the FAO Export Price Index for Rice, an index considered to provide a satisfactory measure of relative movements in export prices, Thai 5% was excluded in the price list (FAO, 2002, 2007).

A review on rice as a differentiated commodity shed two important insights. First, it confirms that few studies have considered segmentation of rice in their price analysis. Second, Thai 5% brokens has often been considered the world reference price for rice but no empirical exercise has been carried out to validate this. This study analyzes the extent of market integration in the international rice market by generating empirical evidence on the cointegration of different export prices. We start our analysis with the assumption that rice is not a homogeneous good. In this context, we establish clusters by rice quality and determine which export markets best represent the world rice price within and across clusters. If export rice prices are cointegrated, they are expected to move together over time through arbitrage, substitution, or both (Ghoshray, 2008). Essentially, this suggests we could expect the same movement whether we look at Thai 5% or Thai100B for example. The results of this study have significant implications for researchers looking at transmission of world to domestic price levels, for traders involved in the import and export of rice, for farmers and consumers affected by changes in the world market , and for governments and policy makers engaged in food sufficiency and stabilization programs.

The study uses 19 monthly average export rice price quotations from January 2000 to July 2012 extracted from the FAO Global Information and Early Warning System food price database and from the Thai Rice Exporters Association. We also include FAO Export Price indices for high and low quality indica to assess their performance with other export prices. We implement our empirical analysis in several steps. First, we examine the time series properties of the data and optimal lag length. Next, we implement cluster analysis to help us define our quality groups. We validate Thai 5% brokens as the benchmark price for rice by examining its bivariate relationships with other export prices. We employ Johansen maximum likelihood procedure to confirm the long-run equilibrium relations and cointegration of price series. Then, we extend the error correction model to a multivariate cointegration analysis by cluster. We test for the Law of One Price, long run exclusion, and weak exogeneity to assess the dynamics of price transmission and determine how prices are related with one another. We build on this information and our knowledge of the rice market system to answer the question – What is the world rice price?

2. BACKGROUND

Nearly 90 percent of the world's rice is produced and consumed in Asia. The principal rice growing region is bounded by Japan on the east, Pakistan on the west, China on the north, and Indonesia on the south. Within this area, the word 'rice' is almost synonymous with 'food' (Asia Society & IRRI, 2010). While production and consumption is geographically concentrated, the world rice market is highly segregated and, often, there is little substitution in both consumption and production (Calpe, 2004; Childs & Burdett, 2000).

There is a wide difference in the quality and types of rice sold in the international market (Barker et al., 1985) (Figure 1). The bulk of the rice traded is medium and long grain[2], usually from indica-type varieties, and is popular throughout South and Southeast Asia. There is a smaller market for short-grain[3], japonica-type varieties grown widely in East Asia and in other temperate zones of the world. Japonica rice is relatively sticky when cooked and has a shorter, thicker grain while indica is less sticky and becomes elongated when cooked. Other rice types (e.g., aromatic, glutinous) tend to be confined to particular areas or regions and are generally traded as specialty items. Aromatic rice, mainly jasmine from Thailand and basmati from India and Pakistan, and glutinous rice, grown mostly in Southeast Asia and used in desserts and ceremonial dishes, typically sell at a premium in world markets.

Moreover, there are three forms of traded rice: rough, brown, and milled (Childs & Burdett, 2000; Childs & Livezey, 2006; Texas A&M University, 2011). Rice that has been harvested from the plant with its husk intact is known as rough or paddy rice. When the hull is removed from rough rice, it is called brown rice. Rice that has had its bran and husk layers removed by milling is called white, table, polished, or milled. Prior to milling, rough rice can also be parboiled, a process of soaking the rice in water and steaming it under intense pressure, which makes the grain less likely to break during milling and pushes nutrients from the bran layer into the kernel. Typically, 100 kilograms of rough rice produce 20 kg of husk and 80 kg of brown rice. The milling process delivers approximately 68 kg of milled rice and 12 kg of bran and other by-products. Of the 68 kg milled rice, about 55 kg are whole grains and the remaining 13 kg are broken grains (Nielsen, 2002; Roche, 1992).

Rice entering the world market is further graded according to quality and percentage of broken grains (Cramer, Wailes, & Shui, 1993). Higher quality rice, which has less than 10 percent brokens, requires a higher degree of milling and grading and commands a price premium. Generally, milling of rice increases its shelf life and provides consumers with a desired physical property – whiteness (Texas A&M University, 2011). Medium quality rice usually includes 10 to 20 percent brokens, while low quality rice has more than 20 percent brokens. A low grade rice with 25 percent brokens will sell less than the price of high-grade rice with 5 percent or less brokens (Barker et al., 1985). Unfortunately, there is a lack of international grading standards to measure and standardize variety and quality differences (McKenzie, 2012).

Calpe (2004) provides an estimate of the volume of rice traded in the global market by type (Table 1). Indica varieties represented 75% of world trade, while japonica and basmati rice accounted for 24%. Most of rice exported are in milled form (77%) and about 15% are exported as parboiled rice. High quality milled rice (i.e., less than 20% broken grains) accounted for 75% of global trade and about one-fourth of total trade is in low quality rice. In short, most of rice traded in the world market are indica

[2] Refers to paddy with 80% of the whole brown rice kernels having a length of 5.5 mm or more.
[3] Refers to paddy with 80% of the whole brown rice kernels having a length of less than 5.5 mm.

varieties, in milled form, and with high milling quality. Unfortunately, while this is the kind of information needed to determine the relevant reference for world price, there is a dearth of country trade data that disaggregates by type.

Figure 1. Rice product differentiation

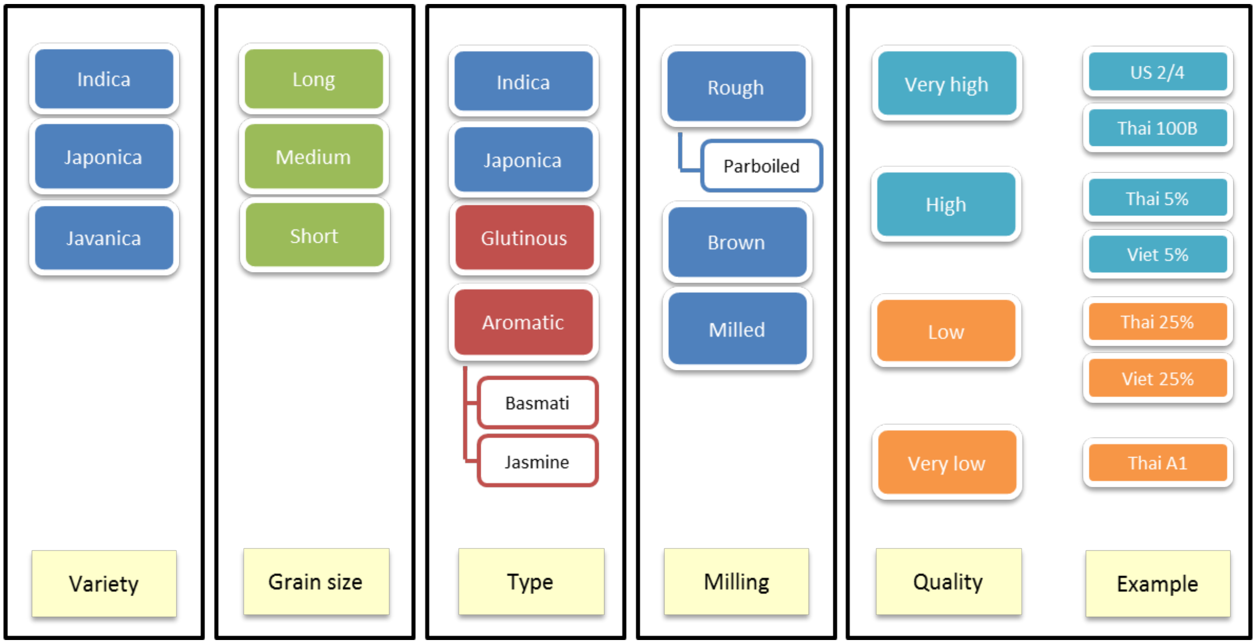


Table 1. Volume of rice trade by type

	1992-1994		2001-2003	
	Quantity (000 t)	Share (%)	Quantity (000 t)	Share (%)
Total Trade	**15,263**		**26,818**	
Variety				
Indica	11,663	76%	20,068	75%
Japonica	2,132	14%	3,186	12%
Aromatic	1,353	9%	3,322	12%
Glutinous	115	1%	242	1%
Degree of Processing				
Rough (paddy)	263	2%	1,122	4%
Brown (husked)	508	3%	1,077	4%
Milled	12,559	82%	20,639	77%
Parboiled	1,934	13%	3,980	15%
Quality				
High Quality	11,781	77%	20,226	75%
Low Quality	3,482	23%	6,592	25%

Source: (Calpe, 2004)

Table 2 summarizes major exporters and importers by types of rice. The bottom part of the table reflects the major players in the world rice market until the early 1980s, while the upper section describes the global trade in the 1990s. Thailand has been a dominant exporter of rice in all types, except for japonica. Vietnam specializes in the export of low quality indica. The U.S. produces and exports all types of rice -- indica, japonica, aromatic, glutinous, rough, and parboiled. India and Pakistan are major exporters of aromatic rice, particularly the basmati variety.

Annex 1 shows several important changes in the structure of rice trade in the last 50 years. Most importantly, it confirms that about 75% of global exports are concentrated on a handful of exporters. Thailand supplies about 30% of rice available in the world market and has been a consistent big exporter in the last three decades. Myanmar was a strong exporter pre-1980, but the momentum was halted because of drastic political and economic transition in the later part of 1988 (Myint & Bauer, 2005). In recent years, domestic production is looking upbeat, and many exporters are watching out again for Myanmar to be one of the top rice exporters (Suwannakij, 2012). The U.S. was the dominant exporter before Thailand and Vietnam came in the picture and took away some markets especially in Asia. Vietnam was a major importer pre-1980, but entered the export market in the mid 1990s after recovering from decades of war and political upheavals (Childs & Burdett, 2000).

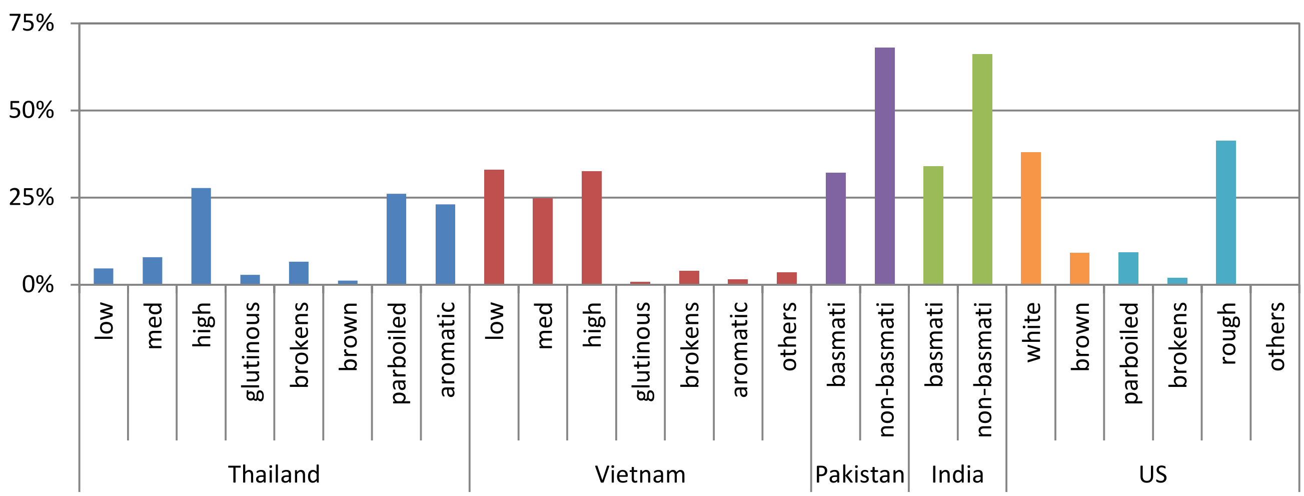
Table 2. Rice traders by type

Sources	**Type**	**Quality**	**Exporter**	**Importer**
(Childs & Burdett, 2000) (Nielsen, 2002)	Indica		Major: Thailand, Vietnam, China, US, Pakistan Minor: Argentina, Uruguay, Guyana, Burma, Surinam	Southeast Asia, South Asia, Sub-Saharan Africa, Latin America
	Japonica		Australia, Egypt, China, EU, US	Northeast Asia, Eastern Mediterranean
	Aromatic		Major: Thailand, India, Pakistan Minor: US	Basmati: Europe, Middle East, US Jasmine: China, US, Singapore
	Glutinous		Major: Thailand Minor: US	Southeast Asia, Japan
	Rough		Major: US Minor: Argentina, Uruguay, Australia	Latin America, Turkey
	Parboiled		Thailand, US, India	Western Europe, Middle East, South Africa
(Slayton, 1984) (Henneberry, 1985) (Jayne, 1993)	Indica, milled	brokens	Thailand, Burma (Myanmar)	Senegal, Madagascar, Mauritania, Gambia, Vietnam
		low	Thailand, Pakistan, China, Burma	Indonesia, West Africa
		medium	US, Thailand, Pakistan	Brazil, Hongkong, Malaysia, Indonesia, Soviet Union
		high	US, Thailand	US, Western Europe, Uruguay, Argentina, Iran, Iraq, Malaysia, Singapore, Hongkong
	Indica, Parboiled	low	Burma (Myanmar), Thailand	Sri Lanka, Bangladesh, Liberia
		high	US, Thailand	Saudi Arabia, Nigeria, EU, Canada, South Africa
	Japonica		Japan, China, Australia	Indonesia, South Korea
	Brown	regular	-	South Korea, Portugal
		parboiled	-	EU, Canada, South Africa

The import side of the world rice market is a different scenario. The share of the top five importers has gone down from as much as 40% in the 1960s to roughly 20% in the last decade, suggesting the entry of numerous small importers. Indonesia was consistently the largest importer until rice imports were banned in 2004 in the country's pursuit of rice self-sufficiency. The Philippines is a traditional rice importer, but made a huge presence in recent years displacing Indonesia as top importer. There is a growing demand for rice in West Africa and the Middle East, as we see four countries outside Asia importing about 3.8 million tons of rice annually in the last decade.

Figure 2 decomposes the types of rice traded by major exporters in the last decade. It confirms that Thailand has focused its markets on high quality indica milled, parboiled, and aromatic rice. Meanwhile, Vietnam is standing-in for the void left by Thailand on lower quality indica milled rice. Pakistan and India are major exporters of basmati rice. India's export ban on non-basmati rice after the 2007-08 food crisis to stabilize domestic food prices further encouraged the expansion of basmati rice exports in recent years. The U.S. is the only major exporter that allows exports of rough rice, mainly to Mexico and Central America, where there is excess milling capacity and lower tariffs on rough rice than on milled rice (Childs & Burdett, 2000). Similarly, the U.S. exports brown rice, mainly to the EU, because of lower import tariff on brown rice than on fully milled rice.

Figure 2. Share of rice exports by type, 2000-2011



Notes: Thailand: low = 20-25% brokens + 35% mix; medium = 10% + 15% brokens; high = 5% + 100B. Vietnam: low = 25% brokens; medium = 10% + 15% brokens; high = 5% brokens. India: non-basmati = brokens + parboiled + others. **Sources of basic data:** Thailand: Thai Rice Exporters Association. Vietnam: USDA FAS GAIN reports for Vietnam. India: Indiastat. Pakistan: Agricultural Statistics of Pakistan 2004-05 & 2010-11 (Pakistan Bureau of Statistics & Ministry of Food, Agriculture and Livestock), Trade Development Authority of Pakistan. US: USDA ERS Rice Yearbooks.

3. RELATED LITERATURE

In 1980, Petzel & Monke examined different types of rice and found that medium- and long-grain indica markets are highly integrated, while japonica and indica varieties somewhat move independently of one another. From this, Falcon and Monke (1980) made the case that Thai 5% brokens can serve as a reasonable indicator of movements in the global market since it is a widely traded variety. This maybe the first explicit statement suggesting the use of Thai 5% as the world reference price. They also observed that the rice market is more fragmented and price information less readily available compared to the wheat market. A few years later, Henneberry (1985) also affirmed the lack of price data by type for rice but reported that the most commonly used world price are the Thai 100% grade B as posted weekly by the Thai Board of Trade and the US No. 2 long grain, brokens not to exceed 4 percent. In 2007, Calpe recaps that the most frequently used export price to represent the market is the Thai 5% brokens, which has been quoted since 1957. Unfortunately, no empirical analysis was carried out to support these claims and the comment that price information is not readily available was more or less overlooked. One example of oversight is in the construction of the FAO Export Price Index for rice. While 18 export quotations are used in its construction, it excludes Thai 5% brokens (Table 3).

There are four major sources of historical export price of rice (Table 4). The longest price series at monthly level is Thai 5% which started in 1960 and maintained by the WB. The FAO recognizes the need to maintain price information, and now offers export price database for 15 rice types with weekly data for Thai A1 and Thai 100%B. When a study talks about world rice price, it will be using with high certainty at least one of the price series listed in the table.

Since most of rice traded in the world market are indica varieties, in milled form, and with high milling quality, it is reasonable to assume Thai 5% as the world reference price. While a few studies, Jayne (1993), Nielsen & Yu (2002), and Ghoshray (2008), accounted for the differences in types of rice available in the world market, there is no robust empirical support to this claim and most analyses have largely ignored rice as a differentiated commodity. Yavapolkul et al. (2006) hinted that an ideal study of rice market integration would include all six major exporters – Thailand, Vietnam, India, US, Pakistan, and China.

Table 3. Rice export prices by type, FAO export price index

High quality indica	**Low quality indica**	**Japonica**	**Aromatic**
Thai 100%B	Thai A1 super	US 2/4	Pakistan basmati
US 2/4	Pakistan IRRI 25%	Australian Calrose	India basmati
Pakistan IRRI 10%	India PR-106 25%	US 2/4-73 (husked)	Thai fragrant 100%B
Vietnam 5%	Vietnam 25%	Egypt 2,5% 178 Camolino[1]	
US parboiled 2/4%		US 1/4% Calrose[1]	
Thai parboiled 100%B			

Note: [1] The composition of the Price Sub-Index for Japonica Rice was revised in September 2007 and now includes two new prices: "Egypt 2,5% 178 Camolino and "US 1/4% Calrose milled". Sources: (FAO, 2002, 2007).

Table 4. Sources of export prices of rice

Source	Details	Type of rice	Start Year
World Bank	Commodity Price Data (a.k.a. Pink Sheet) Frequency: Monthly, Annual http://data.worldbank.org/data-catalog/commodity-price-data	Thai A1 Super Thai 5% Thai 25% Viet 5%	1986 1960 1986 2003
IMF	Primary Commodity Prices Frequency: Monthly http://www.imf.org/external/np/res/commod/index.aspx	Thai 5%	1980
FAO	International commodity prices Frequency: Weekly, Monthly, Annual http://www.fao.org/economic/est/statistical-data/est-cpd/en/	Thai A1 Super Thai 100%B	1989 1989
FAO-GIEWS	Global Information and Early Warning System Food Price Data and Analysis Tool Frequency: Monthly http://www.fao.org/giews/pricetool/	Argentina 10% India 25% Pakistan 25% Pakistan Basmati Thai 25% Thai 5% Thai Fragrant Thai Glutinous Thai Parboiled Thai 100%B Thai A1 Super US California Medium US Long grain 2/4% Viet 25% Viet 5%	2000 1995 2000 2000 2000 2000 2000 2000 2000 2000 2000 2000 2000 2000 2000

Jayne (1993) confirms that indica and japonica varieties frequently move independently of one another, but suggests that price movements are reasonably correlated on an annual basis. Moreover, in a footnote, he disclosed that there were questions whether the world rice price is better approximated by the Thai price, or the price of a prominent U.S. mill port. Nevertheless, he notes a study by Brorsen, Grant, and Chavas (1983) which indicated that the Thai price appears to have a stronger influence on U.S. prices than the other way around. In a review of more than 200 rice market pairs published in the last 10 years focusing on error correction models of PT from international to domestic cereal markets, Greb et al. (2012) documented that Thailand export prices are used for 72% of all rice market pairs and Thai 5% was commonly cited as the world price.

Using 9 rice types, US 2/4, Thai 100, Thai 5%, Viet 5%, Indian 5%, Thai 25%, Viet 25%, Indian 25%, and Thai A1 Super, from January 1990 to December 2001, Nielsen & Yu (2002) strongly suggested that the international rice market is highly segmented. More importantly, they found that Thai market dominates the international rice market and the cointegration results confirm that the Thai market takes on a long run leader role. The study also indicated that Vietnamese rice is considered to be of a lower quality when being compared with rice of a similar grading from other countries, i.e., Viet 25% rice is not integrated with Thai 25% market, but rather with the lower quality Thai A1 rice market. The FAO (2002) recognizes the segmentation of the international market for rice and groups export prices into four categories – high quality indica, low quality indica, japonica, and aromatic -- in the construction of the FAO export price index for rice.

The review on rice as a differentiated commodity shed three important insights. First, it confirms that, while rice is not a homogenous good, few studies have considered segmentation of rice in their price analysis. Second, Thai 5% brokens has been widely considered the world reference price of rice but no empirical exercise has been carried out to validate this. Third, it suggests opportunities for further research, and just timely, as we now see robust interest in this field as indicated by the increasing availability of differentiated rice price data.

4. DATA AND METHODS

A. Data

The data used for this analysis includes 19 monthly average export rice price quotations from January 2000 to July 2012 (n=151) extracted from the FAO Global Information and Early Warning System (GIEWS) food price database and from the Thai Rice Exporters Association (TREA) website (Table 5). The GIEWS was established in 2009 as part of the FAO Initiative on Soaring Food Prices and now serves as the most important source of updated price information. The prices reported in GIEWS are average FOB port[4] quotations in US dollars collected from national official sources and from an international rice broker -- Jackson Son & Company (London) Ltd.[5] It includes differentiated rice prices for major exporters of rice – Thailand, Vietnam, US, and Pakistan.[6] We also track the FAO export price index for high and low quality indica rice starting in January 2001 pulled together from the FAO Rice Market Monitor (RMM) series.[7]

The average price of each series reveals important information on quality differences. Broadly, we observe low quality rice below US$ 300 per ton, medium and high quality rice between US$300 to 400, and premium rice above US$500 per ton in the sample period. The FAO export price indices with base month set at January 2008=100 confirm that prices have gone down since then. In the high quality market, about 2.4 million tons of Thai 5% and Thai100B are traded every year. This is matched by Vietnam's export of Viet 5% and Viet 25% brokens at 2.7 million tons, representing the low quality market.

We examine the time series properties of the data and optimal lag length using the Augmented Dicky-Fuller (ADF) tests that minimizes the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC) lag-order selection statistics. Annex 2 presents the ADF statistics and optimal lags for each price series.

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[4] "Free on Board (FOB) port" means the seller pays for transportation and loading costs of the goods to the port of shipment. The FOB term requires the seller to clear the goods for export. The buyer pays the costs and risks of loss of or damage to the goods from that point.

[5] This is the same source of data reported by FAO international commodity prices for Thai A1 and Thai100%B in http://www.fao.org/economic/est/statistical-data/est-cpd/en/. In March 2012, the company came out with the weekly Live Rice Index (LRI) Reports for more than 70 types of exported rice (see http://livericeindex.com). Although subscription comes with a fee starting in 2013, this is potentially another important source of rice price data in the long run. As a major rice broker and an important source of international prices for rice, it has selected 7 benchmark prices – Thai 100%B, Thai 5% brokens, Thai Hom Mali 100%B, Thai Hom Mali A1 Super, Thai Parboiled 100% STX, Viet 5% brokens, and Pakistan IRRI-6 5% brokens -- and posits that the benchmark prices are more widely traded and considered of greater importance as other grades are often priced from them.

[6] India - Rice (25% broken) is excluded from the analysis because it has 66 missing data points in the sample period.

[7] The RMM can be accessed at http://www.fao.org/economic/est/publications/rice-publications/rice-market-monitor-rmm/en/ .

Using different criteria, the tests confirmed the presence of unit roots in levels and stationarity in first differences. This is supported by the KPSS tests which, for brevity, are not presented here. We use two lags in our analysis as it was selected by our lag order selection stastics in majority of cases. We check for the validity of price series using LM test for residual autocorrelation and eigenvalue stability condition. The Jarque-Bera statistics show that the price variables are not normally distributed indicating non-linearity in the data.[8] We transform our data in logs to address the issue.

Table 5. Data

Variable	Details	Quality[4]	Source	n	Average price[7]	Annual trade[9] (million tons)
arg10	Argentina - Rice (10% broken max)	medium	GIEWS	151	368	0.38[10]
pak25	Pakistan - Rice (25% broken)	low	GIEWS	151	280	0.43[11]
pakb	Pakistan - Rice (Basmati Ordinary)	premium	GIEWS	151	641	0.82
thai5	Thailand: Bangkok - Rice (5% broken)	high	GIEWS	151	359	1.01
thai100	Thailand: Bangkok - Rice (Thai 100% B)[3]	high	GIEWS	151	371	1.35
thai10	Thailand White Rice 10%	medium	TREA[5]	151	358	0.12
thai15	Thailand White Rice 15%	medium	TREA	151	344	0.55
thai25	Thailand: Bangkok - Rice (25% broken)	low	GIEWS	151	324	0.29
thaia1sr[1]	Thailand: Bangkok - Rice (Thai A1 Super)	low	GIEWS	151	278	0.33[12]
thaia1sp[2]	Thailand White Broken Rice A.1 Special	low	TREA	151	277	0.33[12]
thaip	Thailand: Bangkok - Rice (Parboiled 100%)	high	GIEWS	151	377	1.11[13]
thaip5	Thailand: Bangkok - Rice (Parboiled 5%)	high	TREA	151	379	1.11[13]
thaif	Thailand: Bangkok - Rice (Fragrant 100%)	premium	GIEWS	151	630	0.98[14]
thaig	Thailand: Bangkok - Rice (Glutinous 10%)	premium	GIEWS	151	512	0.24
thaihom	Thai Hom Mali Rice Grade B	premium	TREA	151	652	0.98[14]
usmed	USA - Rice (U.S. California Medium Grain)	premium	GIEWS	151	586	0.48[15]
uslong	USA - Rice (U.S. Long Grain 2/4%)	high	GIEWS	151	419	0.75
viet25	Viet Nam - Rice (25% broken)	low	GIEWS	151	290	1.37
viet5	Viet Nam - Rice (5% broken)	high	GIEWS	151	317	1.35
fao_h	Rice Export Price Index – high quality indica	high	RMM[6]	139	89[8]	4.99[16]
fao_l	Rice Export Price Index – low quality indica	low	RMM	139	90[8]	2.49[17]

Notes: [1] A1 Super refers to broken kernels obtained from the milling of WR 15%, 20%, and 25%. [2] A1 Special refers to 100% broken rice similar to A1 Super, but slightly lower in grade than A1 Super. [3] Thai100B is not 100% broken. It is extra well-milled rice with whole grain kernels not less than 60% and brokens not to exceed 5%. [4] Quality based on milling characteristics. [5] TREA=Thai Rice Exporters Association. [6] RMM=FAO Rice Market Monitor. [7] Average price (US$ per ton) for the sample period, Jan 2000 to July 2012. [8] Jan 2008=100, the price indices started in Jan 2001. [9] Estimated annual exports in million metric tons based on countries with disaggregated data using Annex 1 data and percentage shares from Figure 2, and do not cover all exported rice. [10] All Argentina exports. [11] No disaggregated data, estimated using (Pakistan non-basmati * 0.25). [12] Estimated using (Thai brokens + Thai 35% brokens) divided by 2. [13] Estimated using Thai parboiled divided by 2. [14] Estimated using Thai fragrant rice divided by 2. [15] Estimated using US medium + short milled grains. [16] Estimated using thai100 + pak25 + thaip + uslong + viet5. [17] pak25 + thaia1sr + thaia1sp + viet25 + (Indian brokens * 0.25).

[8] While non-normality implies that the subsequent test results must be interpreted with caution, asymptotic results do hold for a wider class of distribution (von Cramon-Taubadel, 1998).

B. Methods

We implement our analysis in several steps. First, we identify rice clusters using agglomerative hierarchical clustering, estimated using average-link distance method. While we have a priori knowledge on differences by milling quality, the lack of standardized grading procedures warrants the need to confirm perceived quality differences in the rice market. Clustering is used to identify structure in an unlabeled data set by objectively organizing data into homogeneous groups where the within-group-object similarity is minimized (Warren Liao, 2005). The similarity (or dissimilarity) between prices is usually measured by Euclidian distance metric. While not the only available distance measure, survey and empirical comparison in Keogh & Kasetty (2003) revealed that the Euclidean distance metric still performs best compared to others when tested on the same dataset with same length (Wang, Smith, Hyndman, & Alahakoon, 2004). We consider average-link clustering (also called minimum variance method), where we take the average distance between all pairs of prices, each variable belonging to a distinct cluster (Murtagh, 1983; Rokach & Maimon, 2005). In other words, the distance between one cluster and another cluster is equal to the average distance from any member of one group to any member of the other group. Agglomerative hierarchical clustering works by grouping the set of prices into a dendrogram. In this method, it assigns each variable in a specific cluster and then merge clusters into larger and larger clusters, until all objects are in a single cluster (Warren Liao, 2005). In the tree of clusters, items are joined by short branches if they are similar to each other, and by increasingly longer branches as their similarity decreases.

Next, we evaluate Thai 5% brokens as the world reference price for rice by examining its bivariate relationships with other export prices. In majority of studies, this is the most cited reference for world rice price. We do this analysis using the Johansen maximum likelihood (ML) procedure (Søren Johansen, 1988). Evidence against the null of no cointegration is taken to indicate that prices co-move and that markets are integrated. We also perform cointegration tests for other possible pairwise combinations to determine significant relationships within and across quality types. Price transmission analysis is essentially a cointegration analysis. We are interested in describing the transmission parameters of cointegrated variables. This is supported by the Engle-Granger Representation Theorem (Engle & Granger, 1987), which states that cointegrated variables have an error correction representation and the same hold in reverse, i.e. if an error correction representation exists between two or more variables, then, the variables are cointegrated.

We employ Johansen procedures in estimating an error correction model (ECM) to confirm the long-run equilibrium relations and cointegration of price series. The vector error correction model (VECM) is a re-parameterization of the standard vector autoregressive (VAR) model which relates the current levels of a set of time series to lagged values of those series. The main advantage of the VECM over the VAR is that it separates the long-run equilibrium (or 'cointegrating') relationship between prices from the short-run dynamics that ensure that any deviations from this long-run equilibrium are 'corrected' and thus only temporary.

The VECM takes the following general form

$$(1) \qquad \Delta P_t = \varphi + \Pi P_{t-1} + \sum_{k=1}^{q} \Gamma_k P_{t-k} + \varepsilon_t$$

where
P_t is an *n* x 1 vector of *n* price variables;
Δ is the difference operator, so $\Delta P_t = P_t - P_{t-1}$;
ε_t is an *n* x 1 vector of error terms;
φ is an *n* x 1 vector of estimated parameters that describe the trend component;
Π is an *n* x *n* matrix of estimated parameters that describe the long-term relationship and the error correction adjustment; and
Γ_k is a set of *n* x *n* matrices of estimated parameters that describe the short-run relationship between prices, one for each of *q* lags included in the model.

The key parameter in the VECM is the $\Pi = \alpha\beta'$ which contains the long-term relationship (β), or the cointegrating vector, and the error correction adjustment (α), which reflects the speed of adjustment. This can be decomposed if the reduced rank (r) of Π is $0 < r < p$, where p is the number of variables. The rank of Π determines the number of stationary linear combinations of the variables in P_t, and is usually estimated using a Johansen trace test (Søren Johansen, 1991). This test allows for more than one cointegrating relationship so is more generally applicable to a vector of prices. We perform diagnostic tests using LM test for residual autocorrelation, eigenvalue stability condition, and Jarque-Bera test of normality to check the validity of price series.

We then extend the VECM to do a multivariate cointegration analysis by cluster. We identify the number of cointegrating relationships using the trace test to determine if long-run relationships between export prices in the same group exist. If the rank is exactly $p-1$, we test whether the restriction imposed on β' makes the linear combination $\beta' P_t$ stationary. In a case of two variables with rank equal to one, the LOP is tested using Likelihood Ratio (LR) tests on whether $\beta' = [1, -1]$. In the multivariate case and with rank equal to $p-1$, the LOP tests whether the price series are pair-wise cointegrated. Asche et al. (1999) have shown that market integration tests based on LOP can provide useful information with respect to commodity aggregation, or segmentation in our case.

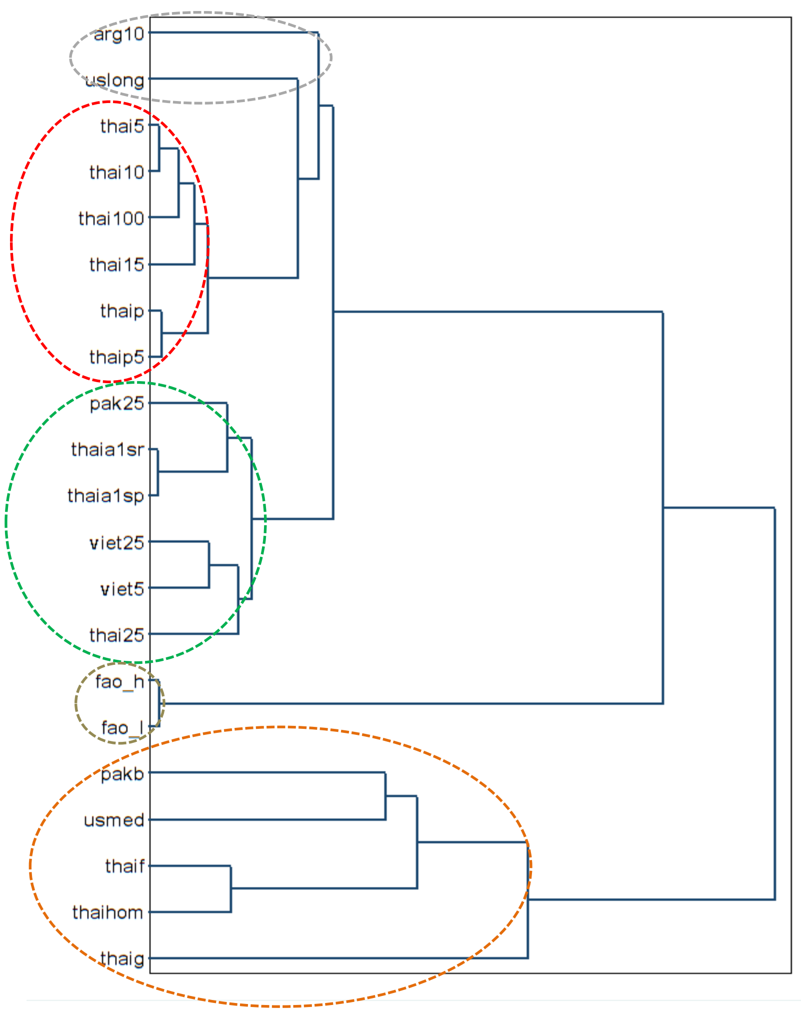
If the rank is found to be less than $p-1$, the LOP cannot be established and tests of long run exclusion and weak exogeneity are performed. We adopt the method carried out by Le Goulven (1999) and Nielsen and Yu (2002). The authors have shown that when cointegrating vectors have been specified, the ECM can be used as the basis for testing for weak exogeneity and exclusion among the price series. Exclusion can test the contribution of specific prices in defining the cointegrating relationship. Weak exogeneity tests for the response of the price series to disequilibrium in the long run relations. Johansen and Juselius (1990) affirms that if all adjustment parameters are zero in one equation, this variable is weakly exogenous for the long-run parameters in the remaining equations. The long run exclusion test amounts to testing for a column of zeros in β', while the weak exogeneity test amounts to testing for a row of zeros in α. Markets may then be classified as long run segmented markets, long run leader markets, long run follower markets, and long run regulator markets depending on the outcome of these tests. We build on this information in answering the question – What is the world rice price?

5. RESULTS AND DISCUSSION

A. Cluster analysis

Figure 3 illustrates the dendrogram from agglomerative hierarchical clustering. It confirms what we know from analyzing trade and quality differences of rice export prices. There appears to be 4 eminent rice clusters: high quality indica, low quality indica, premium rice, and non-Asian rice. Parboiled rice is grouped with the high quality indica, and non-Asian rice (arg10, uslong) is more closely related to this group as well. This is not surprising because parboiled rice is essentially the same but of different processing method. In terms of milling, Arg 10% brokens and US long 2/4% are also high quality indica rice types. In the low quality segment, we observe clustering of 25% brokens, Thai A1, and Viet 5% brokens. It gives support to previous studies that indicate viet5 to be perceived as lower quality rice, even though it is essentially a high quality rice type. The FAO rice export indices are related with both high and low quality clusters, although they are not as closely related as one might have assumed, as evidenced by the longer branches. While we observe clustering in the premium rice category, the similarity is not as tight, which suggests high level of segmentation.

Figure 3. Agglomerative hierarchical clustering dendrogram



B. Bivariate analysis: Thai 5%

Table 6 shows the results of Johansen test of cointegration, and the corresponding estimates of bivariate VECMs with respect to Thai 5% using the Johansen ML procedure estimated with two lags.[9] While an ECM is only valid with cointegrated variables, we present the estimates for non-cointegrated pairs for completeness and make inferences on cointegrated variables only. In the low quality group, we find Thai 5% to be cointegrated with Viet 5% and with the 25% brokens market. There is also evidence of cointegration with other high quality types, basmati, and parboiled. On the other hand, we find that Thai 5% is not cointegrated with either US grain types and Argentina 10%, indicating that Thailand rice is not appropriate reference for the export market in the Latin and North American rice trade. Similarly, we find no statistical evidence for a cointegrating relationship between Thai 5% and the FAO rice export indices.[10] This was expected since Thai 5% was excluded in the construction of the indices. The long-run PT coefficients, β, indicate that changes in Thai 5% are transmitted by roughly 94% to other export prices on average. The transmission is 99% among cointegrated market pairs in Thailand regardless of milling quality.

Table 6. PT estimates with Thai 5%

Variable	Cointegrated	beta	net alpha[1]	alpha1	p-val	alpha2	p-val	half-life[2]
arg10	No	-0.566	0.063	-0.063	0.006	0.009	0.747	10.7
uslong	No	-0.725	0.059	-0.059	0.027	0.038	0.210	11.4
thai10	Yes	-0.988	0.515	-0.515	0.015	-0.259	0.238	1.0
thai100	Yes	-1.005	0.591	-0.591	0.069	-0.388	0.243	0.8
thai15	Yes	-0.986	0.337	0.116	0.495	0.337	0.055	1.7
thaip	Yes	-1.003	0.135	-0.135	0.093	0.037	0.640	4.8
thaip5	Yes	-0.980	0.129	-0.129	0.054	0.014	0.839	5.0
pak25	Yes	-0.791	0.110	-0.060	0.153	0.110	0.009	5.9
thaia1sr	Yes	-0.944	0.089	0.012	0.747	0.089	0.013	7.4
thaia1sp	No	-0.922	0.089	0.009	0.818	0.089	0.016	7.4
viet25	Yes	-0.850	0.235	-0.146	0.007	0.089	0.039	2.6
viet5	Yes	-0.852	0.268	-0.179	0.003	0.089	0.088	2.2
thai25	Yes	-0.998	0.298	0.217	0.020	0.298	0.002	2.0
pakb	Yes	-0.892	0.263	-0.124	0.004	0.139	0.000	2.3
usmed	No	-0.930	0.061	-0.061	0.003	0.026	0.273	11.0
thaif	No	-1.045	0.000	-0.035	0.140	0.028	0.219	-
thaihom	No	-0.939	0.038	-0.038	0.057	0.010	0.602	17.9
thaig	No	-0.915	0.027	-0.013	0.412	0.027	0.089	25.3
fao_h	No	-0.973	0.109	0.008	0.800	0.109	0.011	6.0
fao_l	No	-0.876	0.000	-0.041	0.314	0.077	0.130	-
Average	Yes	-0.935	0.270	-0.139		0.050		2.2
	No	-0.877	0.050	-0.033		0.046		13.6

Notes: The ECM estimates are valid only if the price variable is cointegrated with Thai 5%. [1] Net alpha = $-\alpha_1 + \alpha_2$. We set α_1 and α_2 equal to 0 if not significant at 10% or have wrong signs. [2] Half-life is the time in months that is needed for a given shock to return to half its initial value. It is calculated as $\ln(0.5)/\ln[1-(\text{net alpha})]$.

[9] We also estimated VECMs with 3 lags and found no significant differences with parameters estimated with 2 lags. For parsimony, we report only results estimated with 2 lags.

[10] The interpretation of the PT estimates with the FAO indices are slightly different. Note that the FAO export price indices are not in US$ ton^{-1} units. Hence, the long run elasticity estimate, for example, is the unit change in the index for a unit percentage change in the export price. Nevertheless, we find no statistical evidence for a cointegrating relationship between Thai 5% and the FAO rice export price indices.

For cointegrated pairs, the values of the net adjustment parameter swing from 0.110 for pak25 to 0.591 for thai100. On average, 27% of any deviation from the long-run equilibrium relationship between prices is corrected in the course of one month. The half-life estimates indicate that it takes about 2.2 months to correct one-half of any disequilibrium that emerges due to unexpected price movements in thai5. We look at both coefficients, α_1 and α_2, as we expect some concurrent adjustment to deviations in prices from the long-run relationship with Thai 5%. If two prices are cointegrated, then, α_1 and α_2 must have negative and positive signs, respectively. Thus, if an export price becomes too large relative to Thai 5%, a decrease in price from α_1 in first equation of the VECM, and an increase in price from α_2 in second equation, will drive prices back to the long run equilibrium.

On average, the α_1 coefficients are bigger in absolute values in high quality rice, implying that they respond and adjust faster to price changes in Thai 5% compared to low and premium rice types. We also observe that α_2 coefficients are less frequently significant in high quality rice, suggesting that the high quality export prices are following and adjusting to the movements of Thai 5%. On the other hand, we see that α_2 coefficients in low types are statistically significant which implies contemporaneous response to movements in these prices.

Alpha estimate from the first equation is largest in absolute value with thai10 and thai100, but we observe wrong signs in α_2 for both. In the same line, we find wrong signs in α_1 for thai15 and thai25. This suggests that deviations from the long-run equilibrium are not corrected but rather amplified, which would drive export prices apart over time. Nevertheless, except for thai25, the wrong sign estimates are not statistically significant from zero. In computing for net alpha, we set α_1 and α_2 equal to 0 if not significant at 10% or have the wrong signs.

While we can infer about price relationships with Thai 5% from the bivariate analysis, we want to extend this and present similar PT estimates vis-à-vis other export prices. Annex 3 to 5 report matrix results of cointegration tests and bivariate PT estimates from VECMs with each price series. Out of 21 data series, we observe that some prices are cointegrated with only a few variables, while others are cointegrated with numerous rice export prices. We summarize this finding in Table 7. Included in the first row are premium rice (thaif, thaig, thaihom), rice from outside Asia (usmed, uslong, arg10), and low quality Thai A1 that share the least number of cointegrating relations with other rice export prices. Thai A1 has been used as a world reference price in a few studies, but appears to be not highly cointegrated with other price series. Glutinous rice appears to be a highly segmented market as it is not cointegrated with any of the prices. The middle group includes low (thai25) and medium (thai10, thai15) quality indica, parboiled rice, and the FAO export price indices (fao_h, fao_l). The third row lists rice types that show the most number of cointegrating relations with other export prices. Thai5, thai100, and viet5 are all high quality indica rice, while viet25 and pak25 are low quality indica. Pakistan rice is found to be cointegrated with the most number of export prices.

Table 7. Number of cointegrating relationships

<5:	thaia1sr	thaia1sp	thaig	thaif	thaihom	usmed	uslong	arg10
6-10:	thai10	thai15	thai25	thaip	thaip5	fao_h	fao_l	
>10:	thai5	thai100	viet5	viet25	pak25	pakb		

Source: Annex 3.

C. Multivariate cointegration analysis

The cluster analysis and bivariate estimations provide important information for the next step in the analysis. Preliminary assessment of LOP, LR exclusion, and weak exogeneity tests indicate sensitivity to the variables included (or excluded). Asche et al. (2004) have also observed that results are often sensitive to the dimensionality of the multivariate system and points to the "curse of dimensionality" coined by Bellman (1961). Nevertheless, they suggested bivariate analysis, first and foremost, before continuing with multivariate models.

We summarize our bivariate PT estimates using the groups identified by our clustering analysis (Table 8). The table shows that high and low quality indica are not cointegrated with either arg10 or uslong, the non-Asian cluster. The most number of cointegrating relations are within the high quality indica cluster. Thai5 and thai100 are both cointegrated with all other high quality rice types. It supports the dendrogram which shows that the high quality group has the shortest branches, indicating very high similarity among the variables. The FAO export price indices for high and low quality are cointegrated but they do not share extensive cointegrating relations with other export prices. In the low quality cluster, only pak25 is cointegrated with all types of low quality rice. The high level of segmentation in the premium rice cluster is further evidenced by the low number of cointegrating relations in the group. In fact, only thaif and thaihom, both fragrant rice types, are cointegrated within the premium rice category.

Table 8. Average PT estimates by cluster

			% Cointegration			
Price cluster	**non-asian**	**high**	**low**	**index**	**premium**	**all**
non-asian	0%	0%	0%	25%	50%	**15%**
high	0%	73%	72%	33%	20%	**48%**
low	0%	72%	53%	50%	30%	**48%**
index	25%	33%	50%	100%	30%	**40%**
premium	50%	20%	30%	30%	10%	**25%**
all	**15%**	**48%**	**48%**	**40%**	**25%**	**39%**
			Beta			
non-asian	-1.03	-0.66	-0.75	-0.78	-0.70	**-0.73**
high	-1.54	-1.00	-1.12	-1.09	-1.05	**-1.11**
low	-1.36	-0.90	-1.01	-0.96	-0.93	**-0.98**
index	-1.31	-0.92	-1.06	-1.00	-0.92	**-1.00**
premium	-1.45	-0.95	-1.09	-1.10	-1.00	**-1.07**
all	**-1.41**	**-0.91**	**-1.04**	**-1.02**	**-0.96**	**-1.02**
			Net alpha			
non-asian	0.065	0.073	0.074	0.088	0.087	**0.079**
high	0.049	0.205	0.136	0.101	0.073	**0.123**
low	0.057	0.150	0.125	0.100	0.090	**0.113**
index	0.075	0.098	0.095	0.288	0.093	**0.112**
premium	0.062	0.080	0.087	0.089	0.071	**0.080**
all	**0.058**	**0.134**	**0.111**	**0.106**	**0.081**	**0.105**

Notes: non-asian: arg10, uslong; high: thai5, thai10, thai100, thai15, thaip, thaip5; low: pak25, thaia1sr, thaia1sp, viet25, viet5, thai25; index: fao_h, fao_l; premium: pakb, usmed, thaif, thaihom, thaig. Sources: Annex 3 to 5.

On average, there is a very high degree of cointegration among export prices. The long-run PT coefficients, beta, indicate that 98% of the changes in export prices are transmitted to other export rice prices in the long run. The lowest beta values are in non-Asian rice, specifically that of arg10, suggesting that they do not follow Asian rice prices in the long-run. Roughly 10% of any deviation from the long-run equilibrium relationship between prices is corrected in the course of one month on average. The values of the net adjustment parameter are highest within the high quality cluster, indicating that it takes about 3 months to correct one-half of any disequilibrium that emerges due to unexpected price movements. Slowest adjustment is found in the non-Asian rice cluster.

1. *Law of one price, long run exclusion, and weak exogeneity*

We test LOP on different rice clusters using sequential nesting structure based on the results of the cluster analysis. Table 9 presents our clusters and the results of the trace tests. We examine whether there is a single market for different clusters -- low quality indica, high quality indica, 25% brokens, non-Asian, fragrant, etc. In an earlier study, Nielsen and Yu (2002) found that there are no cointegrating relations among the 5% brokens (Thai, Viet, India); 1 cointegrating relation among the 25% brokens (Thai, Viet, India); 2 cointegrating relations among the high quality market (US 2/4, Thai 100B, Thai 5%, Viet 5% and Ind 5%); and 1 cointegrating relation among the low quality rice types (Thai 25%, Viet 25%, Ind 25%, Thai A1 Super). They also found that Viet 25% is more closely related to the price of Thai A1 than Thai 5%. While our results confirm that there is no single coherent international market for rice, there have been significant changes in the structure of the rice export market since then.

We fail to accept LOP in the non-Asian and fragrant rice category (clusters 1 &2). However, contrary to previous results, we find a coherent market in the 25% brokens (cluster 3). The LOP is maintained even with the inclusion of thai15 and viet5 (cluster 6). The multivariate VECMs confirm that fao_l do not share cointegrating relationships in the low quality rice market. In the high quality segment, we observe strong LOP among thai100, thai10, and thai5. The results show that Viet 5% shares long run relationship both in the low and high quality markets (cluster 5 & 9).

Table 9. Number of cointegrating relationships by rice cluster

Cluster	Category	Variables	Annual trade (million mt)[1]	p[2]	rank(p)[3]
1	non-Asian	usmed uslong arg10	1.6	3	0
2	fragrant	thaif thaihom pakb	2.8	3	1
3	25% market	pak25 thai25 viet25	2.1	3	2
4	25% + a1	pak25 thai25 viet25 thaia1sr thaia1sp	2.8	5	3
5	25% + viet5%	pak25 thai25 viet25 viet5	3.4	4	3
6	25% + viet5% +med	pak25 thai25 viet25 viet5 thai15	4.0	5	4
7	All low	pak25 thai25 viet25 viet5 thai15 thaia1sr thaia1sp fao_l	4.7[4]	8	4
8	high	thai5 thai100 thai10	2.5	3	2
9	high + viet5%	thai5 thai100 thai10 viet5	3.8	4	3
10	high + parboiled	thai5 thai100 thai10 thaip thaip5	4.7	5	3
11	high + med	thai5 thai100 thai10 thai15	3.0	4	2
12	All high	thai5 thai100 thai10 viet5 thaip thaip5 fao_h	6.0[5]	7	3

Notes: [1] See Table 5. [2] p=number of variables. [3] rank(p)=number of cointegrating relationships in the equation. [4] excludes fao_l estimate. [5] excludes fao_h estimate.

While rice types can be broadly categorized to low and high quality clusters, we reject LOP in both segments. We proceed to testing for long run exclusion and weak exogeneity for variables included in clusters 7 (all low) and 12 (all high) (Table 10). The tests point to some evidence that Thai 25%, Pak 25%, Thai15%, and Thai A1 special play leadership roles in low quality rice market. They contribute to long run relations and are weakly exogenous relative to other export prices. Thai A1 Super and Viet 25% are followers in the low quality segment as they do not contribute to the definition of cointegrating relations but are not weakly exogenous in the cluster.

In the high quality cluster, Thai100 and thai10 are viewed as long run leaders as they contribute to the definition of cointegrating relations but they do not respond to deviations from the long run equilibrium. Both Viet 5% and Thai 5% are excludable in the long run relations and are weakly exogenous. We reject long run exclusion and weak exogeneity with parboiled rice and fao_h indicating that they are price followers in the high quality cluster.

Table 10. Tests of long run exclusion and weak exogeneity

Cluster	Category	Variable	LR exclusion test stat		Weak exogeneity test stat		LR exclusion	Weakly exogenous	Classification
7	all low	thaia1sp	17.273	***	0.908		no	yes	leader
		thaia1sr	12.10	***	5.811	**	no	no	follower
		thai15	6.23	**	1.010		no	yes	leader
		viet5	2.44		8.238	***	yes	no	regulator
		viet25	6.08	**	9.062	***	no	no	follower
		thai25	6.57	**	1.192		no	yes	leader
		pak25	16.29	***	1.453		no	yes	leader
		fao_l	0.35		5.738	**	yes	no	regulator
12	all high	thai5	0.49		0.136		yes	yes	segmented
		thaip5	3.06	*	6.641	***	no	no	follower
		thaip	17.58	***	8.556	***	no	no	follower
		viet5	2.01		0.507		yes	yes	segmented
		thai10	2.98	*	0.000		no	yes	leader
		thai100	8.19	***	0.221		no	yes	leader
		fao_h	14.37	***	4.389	**	no	no	follower

D. International reference price

In the light of product segmentation and commodity heterogeneity, it becomes trivial to define a single world price. It seems more apt to say that there can be several candidates for world rice price depending on market pairs included in the analysis. Nevertheless, our analyses on the structure of rice trade and price transmission responses lead us in defining an international reference price (irp) for rice that might be useful for PT analysis.[11]

We recognize that data availability is an important factor in this set-up, so we focus on price series that are maintained regularly and reliably (see Table 4). We propose an alternative reference price that takes into account quality differences, price relationships among export prices, relevance, and data availability. This irp includes export prices -- Thai 5%, Thai100B, Viet 5%, Viet 25%, and Pak 25% -- from the 3 major exporters, Thailand, Vietnam, and Pakistan. We focus only on low and high quality indica markets because the other rice clusters (premium and non-Asian) are found to be highly segmented and do not represent the bulk of global rice trade. These 5 prices account for about 5.5 million tons of yearly exports, pass the test of LOP,[12] and share the most number of cointegrating relations with other export prices.

Both thai5 and thai100 have been mentioned in the literature as the most cited irp for rice. Indeed, they stand for high quality indica rice which represents more than 70% of world rice trade. The 3 countries are also the top major exporters of rice. Thailand is indisputably the largest exporter of rice in the world and represents the high quality segment. Vietnam is the second most important supplier of export rice and represents the lower quality rice segment. We exclude the U.S. because our PT analysis shows that rice markets from outside Asia are highly segmented. We also exclude rice from India because of the focus on basmati rice in recent years. Nevertheless, Pakistan, in the absence of reliable data from India, represents supplies from the South Asian region. Parboiled rice, while gaining importance, is found to be cointegrated with thai5 and thai100.

While we can assign equal weights to the 5 export prices, we have a priori information about their contributions to world rice trade that could be used as weights. In the construction of the irp, we assign 70% weight to high quality rice and 30% weight to low quality rice types.[13] These numbers also represent relative importance in the export volume side as Thailand exports more than 100% of the combined export quantity of Vietnam and Pakistan. Annex 6 graphs the irp vis-à-vis other export prices and shows evident price differences by quality. The irp is consistently below the high quality and premium rice types, and above the low quality rice types.

In multivariate analysis, we have some evidence to show that thai100 is a leader price. However, in bivariate analysis, it appears that thai100 is doing the adjustment to changes in thai5 and not the other way around. In any case, these 2 prices are highly cointegrated. It takes less than 1 month for thai100 to correct one-half of any disequilibrium that emerges due to price movements in thai5. In the low quality cluster, we observe strong LOP in the 25% market. Pak25 is cointegrated with all other prices in both high and low quality indica clusters. Viet5 is technically a high quality rice but is more closely associated with the lower quality segment. Both viet5 and viet25 strongly represent the type of rice Vietnam exports and are also cointegrated with all high quality rice types.[14]

[11] This section serves as an initial attempt to address the issue and is open for feedback.

[12] We cannot reject rank=4 with trace statistic=1.47 < 5% critical value=3.76.

[13] 35% thai100 + 35% thai5 + 10% viet5 + 10% viet25 + 10% pak25 = 70% Thailand + 20% Vietnam + 10% Pakistan.

[14] See Annex 3.

We perform bivariate analysis of this alternative irp for rice to check its robustness in price transmission analysis. Table 11 shows the results of Johansen test of cointegration, and the corresponding estimates of bivariate VECMs using the Johansen ML procedure. We use 2 lags in the underlying VAR for comparability with VECMs estimated with Thai 5% in Table 6. Again, we present the estimates for non-cointegrated pairs for completeness, but make inferences on cointegrated variables only.

The long-run cointegrating vector indicates that changes in the irp are transmitted by roughly 97% to other export prices on average, slightly higher than with thai5. The speed of adjustment parameter in the first cointegrating equation is significant in 12 out of 21 cases, whereas α_2 is found to be statistically significant in only 7 instances, most in low quality rice. For cointegrated pairs, the values of the net alpha range from 0.096 for pak25 to 0.409 for thai5. On average, about 26% of any deviation from the long-run equilibrium relationship between prices is corrected in one period. The half-life estimates indicate that it takes about 2.3 months to correct one-half of any disequilibrium that emerges due to unexpected price movements in irp. The results do not differ significantly from VECM estimates using Thai 5%. It is also not cointegrated with the FAO export price indices. Moreover, it inherited some of the problems encountered with Thai 5% such as wrong signs in α_1 for thai25, thaia1sp, and thaia1sr.

Table 11. PT estimates with the international reference price for rice

Variable	Cointegrated	beta	net alpha[1]	alpha1	p-val	alpha2	p-val	half-life[2]
arg10	No	-0.607	0.064	-0.064	0.005	0.014	0.584	10.5
uslong	No	-0.773	0.061	-0.061	0.026	0.033	0.241	11.0
thai5	Yes	-1.045	0.409	-0.409	0.033	-0.204	0.257	1.3
thai10	Yes	-1.029	0.408	-0.408	0.003	-0.212	0.116	1.3
thai100	Yes	-1.050	0.388	-0.388	0.010	-0.208	0.143	1.4
thai15	No	-1.029	0.000	-0.102	0.534	0.117	0.471	-
thaip	Yes	-1.047	0.162	-0.162	0.032	-0.003	0.966	3.9
thaip5	Yes	-1.025	0.143	-0.143	0.024	-0.012	0.834	4.5
pak25	Yes	-0.832	0.096	-0.071	0.132	0.096	0.031	6.9
thaia1sr	No	-1.007	0.070	0.005	0.899	0.070	0.047	9.6
thaia1sp	No	-0.988	0.070	0.004	0.917	0.070	0.056	9.6
viet25	Yes	-0.888	0.190	-0.190	0.003	0.037	0.440	3.3
viet5	Yes	-0.890	0.252	-0.252	0.001	0.016	0.783	2.4
thai25	No	-1.053	0.279	0.219	0.038	0.279	0.005	2.1
pakb	Yes	-0.928	0.283	-0.144	0.001	0.139	0.000	2.1
usmed	No	-0.980	0.060	-0.060	0.003	0.029	0.168	11.2
thaif	No	-1.117	0.000	-0.033	0.161	0.028	0.151	-
thaihom	No	-1.020	0.035	-0.035	0.069	0.013	0.446	19.5
thaig	No	-1.002	0.027	-0.010	0.516	0.027	0.065	25.3
fao_h	No	-1.017	0.107	0.002	0.957	0.107	0.009	6.1
fao_l	No	-0.931	0.000	-0.051	0.228	0.064	0.193	-
Average	Yes	-0.970	0.259	-0.241		-0.039		2.3
	No	-0.960	0.064	-0.016		0.071		10.4

Notes: The ECM estimates are valid only if the price variable is cointegrated with the irp. [1] Net alpha = $-\alpha_1 + \alpha_2$. We set α_1 and α_2 equal to 0 if not significant at 10% or have wrong signs. [2] Half-life is the time in months that is needed for a given shock to return to half its initial value. It is calculated as $\ln(0.5)$ /ln$[1-$ (net alpha)$]$.

6. CONCLUSION

Our study contributes to the limited discussion on rice as a heterogeneous commodity. We find several important results that are particularly relevant for future studies in rice market analysis. First, we substantiate that the rice market is highly segmented. We accept LOP in the 25% market and in the high quality rice cluster, but reject LOP in the premium and non-Asian rice clusters. We find 4 cointegrating relations among pak25, thai25, viet25, viet5, and thai15 (low quality cluster) and 3 cointegrating relationships among thai5, thai100, thai10, and viet5 (high quality cluster). While Viet 5% is perceived lower quality rice, it tracks both low and high quality clusters.

Second, the high level of segmentation in the rice export market suggests that there is no single answer to our research question. Specifically, there are several international rice prices that could be used as benchmarks. In this line, it is important to understand specific rice types and trade structure to be able to define appropriate irp for a domestic market.

Third, we find that Thai 5% brokens is an acceptable irp for rice. Thailand is the number one exporter of rice in the world and more than 70% of world trade is in high quality indica. Thai5 is also cointegrated with many export prices and, most importantly, long series data is available from the FAO, IMF, and the WB. While we have some indications that Thai 100%B might be another candidate, it is found to be highly correlated and cointegrated with Thai 5%.

Fourth, we propose an irp for indica rice that may be relevant for future PT studies. It takes the weighted average of 5 important export rice prices: thai5, thai100, viet5, viet25, and pak25. The irp passes the test of LOP, is simple to construct, and relies on available data. We consider PT responses from cointegration analysis and from our knowledge of current rice trade structure in setting up this benchmark price. While it is more representative of the international rice trade than using Thai 5% alone, preliminary analysis shows it is highly comparable with thai5, at least in relation with other export prices. A valid test of its performance, vis-à-vis using Thai 5% alone, will come from future world to domestic rice PT analysis.

Two things are worth mentioning. First, we do not discount the importance of Thai 5% in the global rice trade. In fact, in the absence of data, Thai 5% is at best the most reliable irp for rice. It is cointegrated with many other export prices and contributes strongly in defining long run equilibrium relations. Second, we also do not ignore the importance of the FAO export price indices for rice. They include 18 differentiated price quotation covering four important quality types. However, the FAO Export Price indices exclude Thai 5% and do not take into account price relationships within and among quality clusters. The indices are good benchmarks to get overall picture of the global rice market but may not be the best data for empirical price analysis.

Our study implies that failure to find cointegrating relations from world to domestic rice markets can be a result of failure to effectively define the appropriate irp. For example, a recent study by Greb et al (2012) reported only 55% cointegration from world to domestic markets using FAO GIEWS data and Thai 5% as the international rice price for all markets. In PT analysis, we find that it is imperative to examine the types of rice and to discuss the relevance of specific markets to the benchmark price based on understanding of rice trade structure. This study affirms the importance of having up-to-date and reliable sources of rice prices both in the export and domestic markets, accounting for differences in quality.

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Annex 1. Changing structure of world rice trade, 1960-2009

IMPORTERS

1960-70			1970-80			1980-90			1990-2000			2000-09		
India	799,185	10%	**Indonesia**	1,397,670	15%	**Iran**	576,074	5%	**Indonesia**	1,608,874	8%	**Philippines**	1,499,304	5%
Indonesia	715,180	9%	**Viet Nam**	454,610	5%	**USSR**	553,500	4%	**Iran**	924,741	5%	**Nigeria**	1,091,019	4%
Viet Nam	709,379	9%	**Rep of Korea**	432,116	5%	**Iraq**	476,900	4%	**Brazil**	865,976	4%	**Iran**	971,677	4%
Sri Lanka	459,283	6%	**USSR**	376,099	4%	**Saudi Arabia**	394,907	3%	**Saudi Arabia**	626,267	3%	**Saudi Arabia**	937,323	3%
Japan	398,744	5%	**Hong Kong**	367,923	4%	**Nigeria**	390,489	3%	**Bangladesh**	612,521	3%	**Senegal**	844,966	3%
Top 5	3,081,771	40%	**Top 5**	3,028,418	32%	**Top 5**	2,391,870	19%	**Top 5**	4,638,379	23%	**Top 5**	5,344,289	19%
ROW	4,693,091	60%	**ROW**	6,499,228	68%	**ROW**	10,022,607	81%	**ROW**	15,300,415	77%	**ROW**	22,135,937	81%

EXPORTERS

1960-70			1970-80			1980-90			1990-2000			2000-09		
USA	1,471,960	19%	**USA**	2,103,757	22%	**Thailand**	4,352,595	34%	**Thailand**	5,606,990	27%	**Thailand**	8,489,948	29%
Thailand	1,419,885	18%	**Thailand**	1,864,585	20%	**USA**	2,479,733	19%	**Viet Nam**	2,696,486	13%	**Viet Nam**	4,160,289	14%
China	1,287,406	17%	**China**	1,731,290	18%	**Pakistan**	1,047,801	8%	**USA**	2,644,605	13%	**India**	3,925,360	14%
Myanmar	1,097,859	14%	**Pakistan**	687,690	7%	**China**	896,439	7%	**India**	2,112,164	10%	**USA**	3,234,934	11%
Egypt	441,323	6%	**Myanmar**	486,248	5%	**Italy**	580,917	5%	**China**	1,627,313	8%	**Pakistan**	2,557,926	9%
Top 5	5,718,433	74%	**Top 5**	6,873,570	72%	**Top 5**	9,357,484	74%	**Top 5**	14,687,558	72%	**Top 5**	22,368,457	77%
ROW	2,054,551	26%	**ROW**	2,672,388	28%	**ROW**	3,369,060	26%	**ROW**	5,806,427	28%	**ROW**	6,605,093	23%

Notes: Average annual trade volume in each period. ROW: rest of the world. Source of basic data: FAOSTAT.

Annex 2. Unit root tests and lag length selection

		lag		adf	
variable	criterion	level	diff	level	diff
arg10	FPE	2	1	0.380	-7.169
arg10	AIC	2	1	0.380	-7.169
arg10	SBIC	2	1	0.380	-7.169
arg10	HQIC	2	1	0.380	-7.169
pak25	FPE	3	2	0.844	-6.377
pak25	AIC	3	2	0.844	-6.377
pak25	SBIC	2	1	0.731	-7.029
pak25	HQIC	3	2	0.844	-6.377
pakb	FPE	2	1	0.774	-8.046
pakb	AIC	2	1	0.774	-8.046
pakb	SBIC	2	1	0.774	-8.046
pakb	HQIC	2	1	0.774	-8.046
usmed	FPE	2	1	0.446	-6.077
usmed	AIC	2	1	0.446	-6.077
usmed	SBIC	2	1	0.446	-6.077
usmed	HQIC	2	1	0.446	-6.077
uslong	FPE	2	1	0.538	-5.933
uslong	AIC	2	1	0.538	-5.933
uslong	SBIC	2	1	0.538	-5.933
uslong	HQIC	2	1	0.538	-5.933
viet25	FPE	2	4	0.494	-6.883
viet25	AIC	2	4	0.494	-6.883
viet25	SBIC	2	1	0.494	-6.613
viet25	HQIC	2	1	0.494	-6.613
viet5	FPE	3	4	0.600	-5.805
viet5	AIC	3	4	0.600	-5.805
viet5	SBIC	3	2	0.600	-6.423
viet5	HQIC	3	2	0.600	-6.423
thai25	FPE	2	1	0.930	-6.572
thai25	AIC	2	1	0.930	-6.572
thai25	SBIC	2	1	0.930	-6.572
thai25	HQIC	2	1	0.930	-6.572
thai5	FPE	2	1	0.777	-6.524
thai5	AIC	2	1	0.777	-6.524
thai5	SBIC	2	1	0.777	-6.524
thai5	HQIC	2	1	0.777	-6.524
thaif	FPE	2	1	0.806	-6.739
thaif	AIC	2	1	0.806	-6.739
thaif	SBIC	2	1	0.806	-6.739
thaif	HQIC	2	1	0.806	-6.739
thaig	FPE	3	2	0.969	-6.153
thaig	AIC	3	2	0.969	-6.153
thaig	SBIC	3	2	0.969	-6.153
thaig	HQIC	3	2	0.969	-6.153

		lag		adf	
variable	criterion	level	diff	level	diff
thaip	FPE	3	2	0.730	-6.338
thaip	AIC	3	2	0.730	-6.338
thaip	SBIC	2	1	0.681	-6.796
thaip	HQIC	2	1	0.681	-6.796
thai100	FPE	2	1	0.814	-6.792
thai100	AIC	2	1	0.814	-6.792
thai100	SBIC	2	1	0.814	-6.792
thai100	HQIC	2	1	0.814	-6.792
thaia1sr	FPE	3	2	1.026	-5.994
thaia1sr	AIC	3	2	1.026	-5.994
thaia1sr	SBIC	3	2	1.026	-5.994
thaia1sr	HQIC	3	2	1.026	-5.994
thaihom	FPE	2	1	0.436	-6.224
thaihom	AIC	2	1	0.436	-6.224
thaihom	SBIC	2	1	0.436	-6.224
thaihom	HQIC	2	1	0.436	-6.224
thai10	FPE	3	2	0.800	-5.751
thai10	AIC	3	2	0.800	-5.751
thai10	SBIC	2	1	0.770	-7.043
thai10	HQIC	3	2	0.800	-5.751
thai15	FPE	3	2	0.894	-5.776
thai15	AIC	3	2	0.894	-5.776
thai15	SBIC	2	1	0.847	-6.971
thai15	HQIC	3	2	0.894	-5.776
thaia1sp	FPE	3	2	0.975	-5.755
thaia1sp	AIC	3	2	0.975	-5.755
thaia1sp	SBIC	3	2	0.975	-5.755
thaia1sp	HQIC	3	2	0.975	-5.755
thaip5	FPE	3	2	0.643	-6.047
thaip5	AIC	3	2	0.643	-6.047
thaip5	SBIC	3	2	0.643	-6.047
thaip5	HQIC	3	2	0.643	-6.047
fao_h	FPE	2	1	0.759	-5.525
fao_h	AIC	2	1	0.759	-5.525
fao_h	SBIC	2	1	0.759	-5.525
fao_h	HQIC	2	1	0.759	-5.525
fao_l	FPE	2	4	0.569	-4.721
fao_l	AIC	2	4	0.569	-4.721
fao_l	SBIC	2	1	0.569	-5.812
fao_l	HQIC	2	1	0.569	-5.812

Annex 3. Cointegration tests

Variable	arg10	uslong	thai5	thai10	thai100	thai15	thaip	thaip5	pak25	thaia1sr	thaia1sp	viet25	viet5	thai25	fao_h	fao_l	pakb	usmed	thaif	thaihom	thaig
arg10		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0
uslong	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
thai5	0	0		1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0
thai10	0	0	1		1	0	1	1	1	0	0	1	1	1	0	0	1	0	0	0	0
thai100	0	0	1	1		1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0
thai15	0	0	1	0	1		0	0	1	0	1	1	1	1	0	0	1	0	0	0	0
thaip	0	0	1	1	1	0		0	1	0	0	1	1	0	1	1	1	0	0	0	0
thaip5	0	0	1	1	1	0	0		1	0	0	1	1	0	1	1	1	0	0	0	0
pak25	0	0	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	0	0	0
thaia1sr	0	0	1	0	1	0	0	0	1		1	0	0	0	0	0	1	0	0	0	0
thaia1sp	0	0	0	0	1	1	0	0	1	1		0	0	0	0	0	1	0	0	0	0
viet25	0	0	1	1	1	1	1	1	1	0	0		0	1	1	1	1	1	0	0	0
viet5	0	0	1	1	1	1	1	1	1	0	0	0		1	1	1	1	1	0	0	0
thai25	0	0	1	1	1	1	0	0	1	0	0	1	1		0	0	1	0	0	0	0
fao_h	1	0	0	0	0	0	1	1	1	0	0	1	1	0		1	1	0	0	0	0
fao_l	0	0	0	0	0	0	1	1	1	0	0	1	1	0	1		1	1	0	0	0
pakb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0	0	0	0
usmed	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0		0	0	0
thaif	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0
thaihom	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0
thaig	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: using trace test with 2 lags, 1=yes (cointegrated).

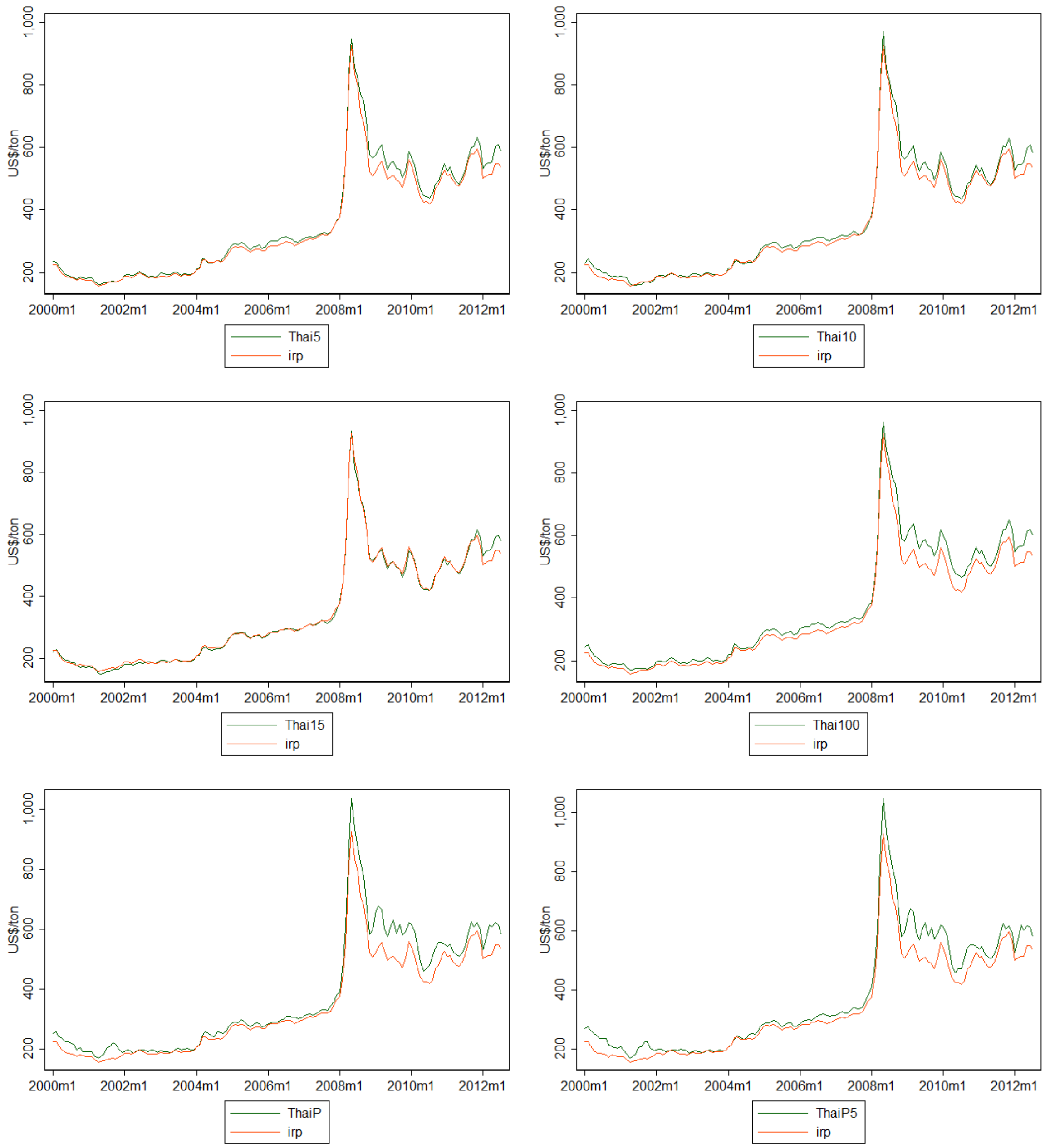
Annex 4. Beta

Variable	arg10	uslong	thai5	thai10	thai100	thai15	thaip	thaip5	pak25	thaia1sr	thaia1sp	viet25	viet5	thai25	fao_h	fao_l	pakb	usmed	thaif	thaihom	thaig
arg10		-0.77	-0.57	-0.58	-0.57	-0.58	-0.59	-0.60	-0.73	-0.61	-0.62	-0.72	-0.72	-0.57	-0.68	-0.74	-0.66	-0.61	-0.59	-0.66	-0.61
uslong	-1.30		-0.72	-0.75	-0.72	-0.75	-0.73	-0.76	-0.94	-0.76	-0.78	-0.92	-0.93	-0.72	-0.81	-0.87	-0.85	-0.82	-0.69	-0.77	-0.76
thai5	-1.77	-1.38		-1.01	-1.00	-1.01	-1.00	-1.02	-1.26	-1.06	-1.08	-1.18	-1.17	-1.00	-1.03	-1.14	-1.12	-1.08	-0.96	-1.06	-1.09
thai10	-1.73	-1.33	-0.99		-0.98	-1.00	-0.99	-1.01	-1.24	-1.05	-1.07	-1.17	-1.16	-0.98	-1.04	-1.14	-1.11	-1.06	-0.94	-1.05	-1.08
thai100	-1.77	-1.38	-1.00	-1.02		-1.02	-1.00	-1.02	-1.27	-1.06	-1.09	-1.18	-1.18	-1.01	-1.05	-1.15	-1.12	-1.08	-0.96	-1.08	-1.10
thai15	-1.72	-1.34	-0.99	-1.00	-0.98		-0.99	-1.01	-1.23	-1.05	-1.06	-1.16	-1.16	-0.99	-1.02	-1.12	-1.11	-1.06	-0.94	-1.05	-1.08
thaip	-1.71	-1.36	-1.00	-1.01	-1.00	-1.01		-1.02	-1.30	-1.08	-1.09	-1.21	-1.20	-0.99	-1.07	-1.17	-1.13	-1.08	-0.95	-1.06	-1.08
thaip5	-1.66	-1.32	-0.98	-0.99	-0.98	-0.99	-0.98		-1.28	-1.06	-1.06	-1.20	-1.18	-0.97	-1.06	-1.16	-1.11	-1.05	-0.92	-1.03	-1.05
pak25	-1.37	-1.06	-0.79	-0.80	-0.79	-0.81	-0.77	-0.78		-0.83	-0.84	-0.95	-0.96	-0.80	-0.82	-0.88	-0.93	-0.87	-0.72	-0.80	-0.81
thaia1sr	-1.65	-1.32	-0.94	-0.95	-0.94	-0.96	-0.93	-0.95	-1.21		-1.02	-1.17	-1.20	-0.95	-0.96	-1.07	-1.09	-1.03	-0.92	-1.01	-1.01
thaia1sp	-1.62	-1.29	-0.92	-0.94	-0.92	-0.94	-0.92	-0.94	-1.19	-0.98		-1.17	-1.19	-0.93	-0.97	-1.08	-1.07	-1.02	-0.90	-0.99	-1.00
viet25	-1.40	-1.08	-0.85	-0.86	-0.84	-0.86	-0.83	-0.83	-1.06	-0.85	-0.86		-1.01	-0.86	-0.87	-0.94	-1.00	-0.90	-0.78	-0.76	-0.81
viet5	-1.38	-1.07	-0.85	-0.86	-0.85	-0.87	-0.83	-0.85	-1.04	-0.83	-0.84	-0.99		-0.85	-0.89	-0.96	-0.99	-0.89	-0.76	-0.76	-0.78
thai25	-1.75	-1.38	-1.00	-1.02	-0.99	-1.01	-1.01	-1.03	-1.25	-1.05	-1.08	-1.16	-1.17		-1.01	-1.11	-1.12	-1.08	-0.96	-1.06	-1.08
fao_h	-1.49	-1.24	-0.97	-0.97	-0.96	-0.99	-0.93	-0.95	-1.22	-1.06	-1.08	-1.15	-1.13	-1.00		-1.08	-1.02	-1.01	-0.88	-0.95	-1.02
fao_l	-1.36	-1.14	-0.88	-0.88	-0.87	-0.90	-0.86	-0.87	-1.14	-0.94	-0.96	-1.06	-1.04	-0.89	-0.92		-0.95	-0.92	-0.77	-0.84	-0.85
pakb	-1.52	-1.17	-0.89	-0.90	-0.89	-0.90	-0.89	-0.90	-1.07	-0.92	-0.93	-1.00	-1.01	-0.89	-0.98	-1.05		-0.97	-0.87	-0.96	-0.97
usmed	-1.64	-1.22	-0.93	-0.94	-0.92	-0.94	-0.93	-0.95	-1.15	-0.97	-0.99	-1.11	-1.12	-0.93	-0.98	-1.07	-1.04		-0.90	-1.00	-1.02
thaif	-1.70	-1.45	-1.04	-1.06	-1.04	-1.06	-1.05	-1.08	-1.38	-1.09	-1.11	-1.29	-1.31	-1.04	-1.11	-1.25	-1.15	-1.11		-1.10	-1.14
thaihom	-1.52	-1.29	-0.94	-0.95	-0.93	-0.95	-0.94	-0.97	-1.26	-0.99	-1.01	-1.31	-1.32	-0.94	-1.06	-1.18	-1.04	-1.00	-0.91		-1.02
thaig	-1.64	-1.32	-0.92	-0.93	-0.91	-0.93	-0.93	-0.96	-1.23	-0.99	-1.00	-1.24	-1.28	-0.92	-1.08	-1.23	-1.04	-0.98	-0.88	-0.98	

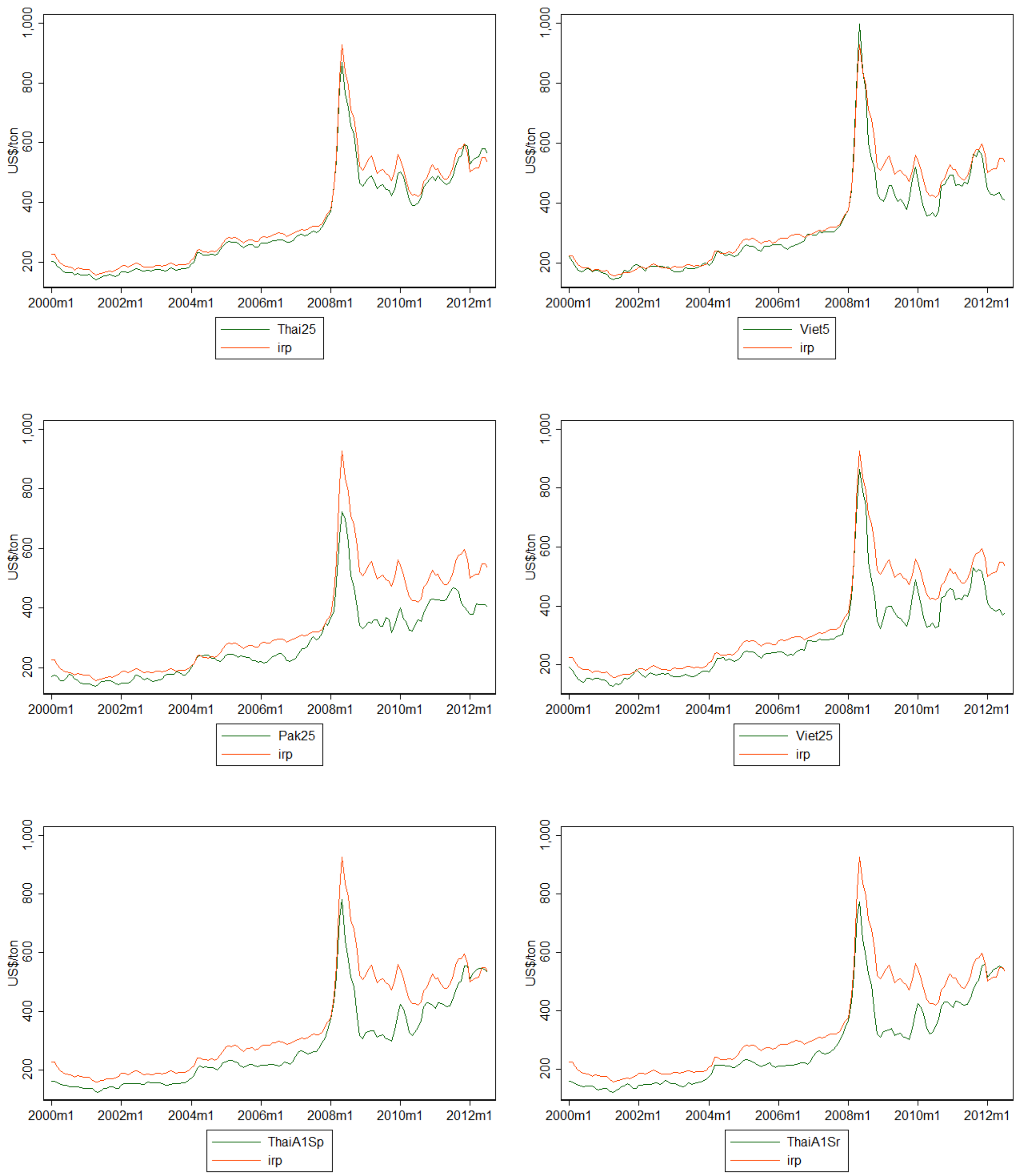
Annex 5. Net alpha

Variable	arg10	uslong	thai5	thai10	thai100	thai15	thaip	thaip5	pak25	thaia1sr	thaia1sp	viet25	viet5	thai25	fao_h	fao_l	pakb	usmed	thaif	thaihom	thaig
arg10		0.07	0.06	0.06	0.06	0.07	0.08	0.08	0.07	0.06	0.06	0.06	0.06	0.06	0.12	0.10	0.08	0.07	0.13	0.13	0.05
uslong	0.06		0.06	0.06	0.06	0.06	0.12	0.12	0.08	0.06	0.06	0.12	0.12	0.07	0.10	0.04	0.15	0.12	0.05	0.05	0.04
thai5	0.04	0.04		0.51	0.59	0.33	0.14	0.13	0.09	0.08	0.08	0.20	0.23	0.30	0.11	0.05	0.23	0.06	0.00	0.04	0.03
thai10	0.04	0.04	0.51		0.00	0.52	0.00	0.00	0.09	0.08	0.09	0.19	0.22	0.29	0.11	0.08	0.24	0.05	0.00	0.03	0.02
thai100	0.04	0.04	0.59	0.00		0.31	0.15	0.14	0.08	0.08	0.08	0.19	0.22	0.25	0.12	0.05	0.23	0.05	0.00	0.04	0.02
thai15	0.04	0.05	0.34	0.52	0.32		0.14	0.12	0.09	0.08	0.08	0.15	0.18	0.43	0.09	0.00	0.24	0.06	0.00	0.04	0.03
thaip	0.04	0.09	0.13	0.00	0.15	0.13		0.00	0.07	0.06	0.06	0.10	0.12	0.14	0.18	0.14	0.24	0.05	0.00	0.03	0.03
thaip5	0.05	0.09	0.13	0.00	0.14	0.12	0.00		0.07	0.06	0.06	0.09	0.11	0.13	0.16	0.13	0.24	0.08	0.04	0.03	0.03
pak25	0.05	0.08	0.11	0.11	0.10	0.11	0.09	0.09		0.11	0.11	0.27	0.25	0.11	0.13	0.17	0.28	0.07	0.05	0.03	0.05
thaia1sr	0.04	0.04	0.09	0.09	0.08	0.09	0.06	0.06	0.09		0.00	0.15	0.13	0.00	0.03	0.05	0.19	0.04	0.04	0.03	0.05
thaia1sp	0.04	0.04	0.09	0.09	0.08	0.09	0.06	0.06	0.09	0.00		0.15	0.13	0.00	0.05	0.05	0.19	0.04	0.04	0.03	0.05
viet25	0.04	0.11	0.23	0.22	0.22	0.18	0.12	0.11	0.26	0.18	0.17		0.00	0.23	0.16	0.15	0.29	0.10	0.07	0.04	0.06
viet5	0.04	0.11	0.27	0.25	0.26	0.21	0.15	0.13	0.24	0.15	0.15	0.00		0.26	0.16	0.14	0.33	0.11	0.07	0.04	0.06
thai25	0.04	0.05	0.30	0.28	0.25	0.42	0.14	0.12	0.09	0.00	0.00	0.20	0.22		0.08	0.03	0.23	0.05	0.00	0.04	0.03
fao_h	0.08	0.08	0.11	0.12	0.12	0.10	0.19	0.18	0.11	0.06	0.05	0.13	0.15	0.08		0.28	0.26	0.07	0.04	0.09	0.00
fao_l	0.07	0.06	0.00	0.09	0.00	0.00	0.14	0.14	0.14	0.05	0.05	0.13	0.14	0.07	0.30		0.25	0.10	0.05	0.05	0.03
pakb	0.05	0.13	0.26	0.26	0.26	0.26	0.28	0.27	0.26	0.21	0.20	0.29	0.32	0.26	0.28	0.25		0.12	0.13	0.06	0.07
usmed	0.04	0.10	0.06	0.06	0.06	0.06	0.05	0.09	0.06	0.04	0.04	0.09	0.10	0.06	0.06	0.08	0.12		0.06	0.06	0.02
thaif	0.07	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.05	0.05	0.00	0.02	0.04	0.11	0.05		0.15	0.03
thaihom	0.09	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.09	0.04	0.06	0.06	0.17		0.00
thaig	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.04	0.03	0.01	0.03	0.07	0.02	0.03	0.00	

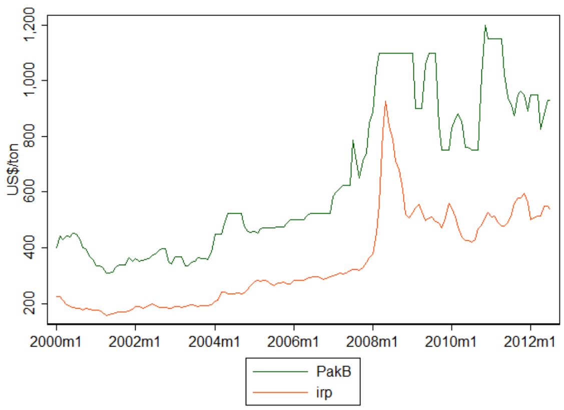
Annex 6. Export rice prices versus international reference price

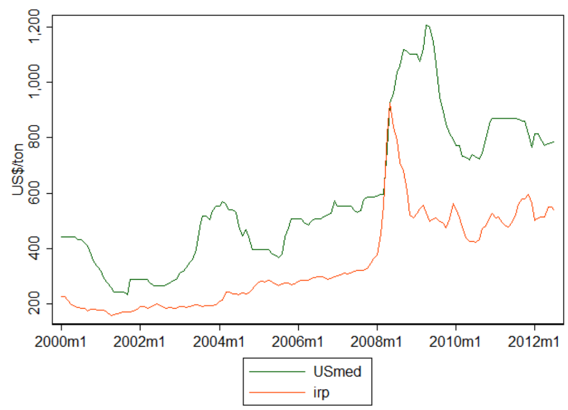


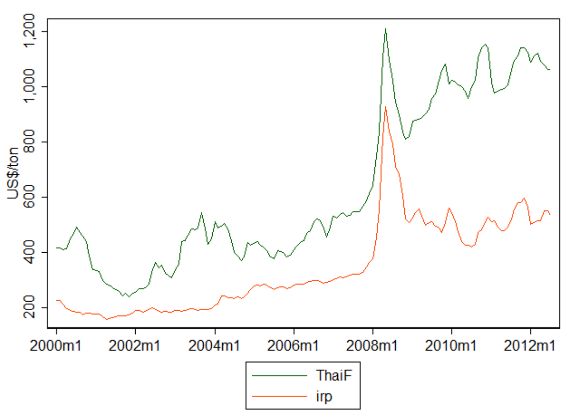
Annex 6. Export rice prices versus the international reference price (continued)

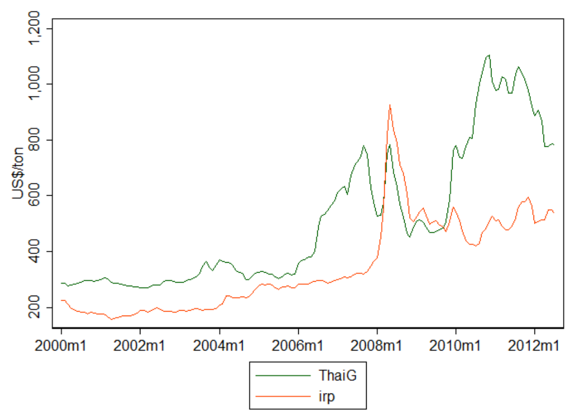


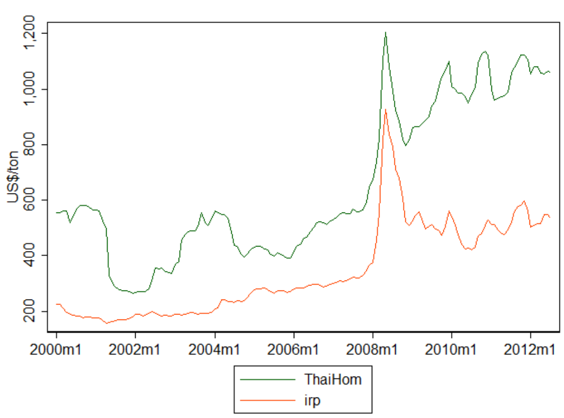
Annex 6. Export rice prices versus the international reference price (continued)











Annex 6. Export rice prices versus the international reference price (continued)