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The changing structure of the world rice market, 1950–2000

D. Dawe *

International Rice Research Institute, Los Baños, Laguna, Philippines

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Abstract

The world rice market has been unstable for much of its post-world war II history, with prices volatile and the availability of supplies uncertain. These characteristics, exemplified by the world food crisis of the mid-1970s, influenced domestic price and production policies in a number of Asian countries. However, the structure of the world rice market has evolved and changed during the past 50 years. This paper identifies three distinct phases in the history of the market based on trends in the level and stability of production and the trade orientation of major exporters. The level and stability of production increased steadily over the entire period. Exporters have generally been active in the world market, with the period 1965–1981 being an important exception. Since the mid-1980s, prices have been low and quite stable, and the patterns identified in the paper suggest that prices will remain so in the future. The policy implication is that Asian rice importers can afford to rely more on the world market than was warranted in the past.

Introduction

Nearly 70% of the world's poor live in Asia (UNDP, 1997), a continent where rice is by far the dominant staple food. The world rice market has traditionally been a particularly unstable commodity market (Falcon and Monke, 1979–1980; Monke and Pearson, 1991; Siamwalla and Haykin, 1983), where the availability of supplies is uncertain and prices are highly variable. There are several characteristics that made

* Present address: DAPO Box 7777, Metro Manila, Philippines. Tel.: +632-845-0563; fax: +632-891-1292.

E-mail address: d.dawe@cgiar.org (D. Dawe).

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the world rice market more unstable than world markets for other grains such as wheat and maize: the geographic concentration of rice production, a thin and fragmented world market with high transaction costs in trading, low domestic price elasticities of demand, and relatively low world stockholdings (Jayne, 1993).

Price variability on the world rice market has profoundly affected rice policies throughout Asia via at least two main channels. First, governments pursued policies such as expansion of irrigation and implementation of fertilizer and credit subsidies in order to increase domestic rice production and approach or attain self-sufficiency, thus reducing reliance on the world market. Secondly, most rice producing countries have pursued price stabilization policies in order to mitigate the impact of changing world prices on domestic prices when some exposure to the world market was too costly to avoid (Dawe, 2001). However, the world rice market has undergone continual evolution and change during the past half-century, and it is not the same world market today that it was in the past. These changes have affected both the level and the variability of world rice prices.

One notable feature of its evolution has been the low level of world rice prices from the mid-1980s to the present. The transition to this new period of lower prices was not gradual, but was instead concentrated within a period of 4 years, 1982–1985. From 1950 to 1981, world rice prices averaged about US$934/ton (constant year 2001 prices), with no distinct trend over time (Fig. 1). Then, from 1981 to 1985, world prices plunged precipitously, falling by 62% in just 4 years. From 1985 to 1998, prices averaged about US$355/ton, without any distinct time trend during this latter period. Most recently, prices have plunged once more, falling 48% between 1998 and 2001 to a new low of US$173/ton.

Just as the level of prices has changed considerably during the past 50 years, so has the variability of prices. Three distinct phases can be identified. From 1950 to 1964, prices were relatively stable, as measured by either the root mean square error

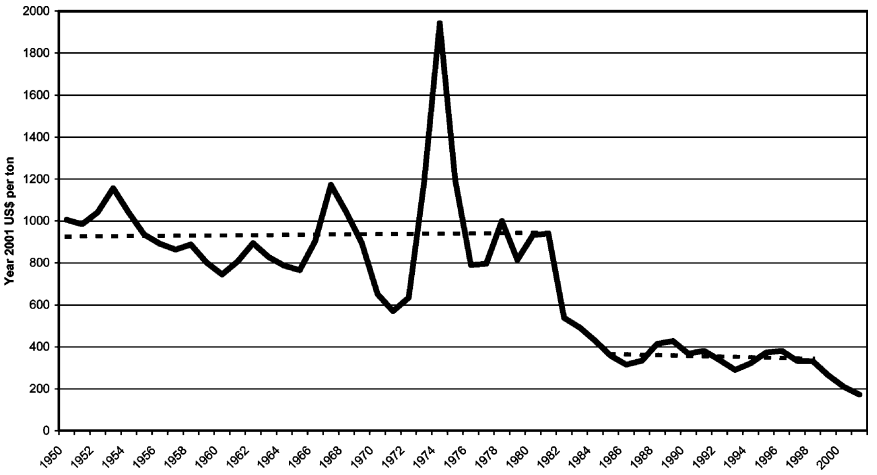

Fig. 1. Inflation-adjusted world market rice prices, 1950–2001, 100Bs, FOB Bangkok. Dashed lines indicate time trends for 1950–1981 and 1985–1998.

(RMSE) from a regression of real price versus a time trend, or the average absolute value of the percentage price change from year to year (Table 1). From 1965 to 1981, prices were substantially more variable. This period includes the world food crisis of 1973–1975, an event that was important in shaping the attitude of Asian policymakers toward instability. Finally, from 1985 to 1998, world prices were relatively stable once again. (Price stability in a very short time span is not easy to measure in a meaningful manner, so the transition period from 1982 to 1984 is ignored in terms of measuring price variability, as is the recent decline from 1999 to 2001.) The conclusion that rice prices have been more stable during the past 20 years (albeit punctuated with two sharp, and apparently permanent, declines) is consistent with the conclusion in Sarris (2000).

Thus, to summarize, the pre-Green Revolution period from 1950 to 1964 was characterized by high and stable prices. The Green Revolution period from 1965 to 1981, when modern fertilizer-responsive varieties were adopted in many countries, was a period of high and unstable prices (1965–1981).[1] The years 1982–1984 marked a short transition to a post-Green Revolution regime of low and stable prices from 1985 to 1998 (see Table 2 for a summary of the characteristics of each period). Most recently, from 1999 to 2001, prices have plunged once again.

The main objective of this paper is to explain these shifts in the behavior of prices in terms of technological changes and political disturbances that have affected rice production and trade. For example, why were prices relatively unstable in the middle of the past half-century, yet relatively stable at other times? Perhaps more important, can these factors provide insights into the future of the world rice market in terms of the level and stability of prices?

Table 1
Stability of world market rice prices

Period	Average absolute value of annual price changes (%)	RMSE (from regression of real price vs. time trend) normalized by average price
1950–1964	7	0.078
1965–1981	24	0.341
1985–1998	11	0.111

Source of raw data: IMF (2002).

[1] When the words ‘unstable’ and ‘instability’ are used in this paper, the meaning is synonymous with a high level of variability from trend. Similarly, the words ‘stable’ and ‘stability’ are synonymous with a low amount of variability from trend.

Table 2
Characteristics of the world rice economy, selected periods

Period	1950–1964	1965–1981	1985–1998
	Pre-green revolution	Green revolution	Post-green revolution
Production structure			
Level (per capita)	Low	Medium	High
Variability	High	Medium	Low
Trade structure			
Number of commercially oriented exporters	Many	Few	Many
Prices			
Level	High	High	Low
Variability	Low	High	Low
Average yield, world (ton ha^{-1})	1.88	2.42	3.54
Modern variety adoption as percentage of planted area, end of period			
Bangladesh	0	22	61
India	0	48	74
Indonesia	0	61	81
Myanmar	0	53	61
Philippines	0	79	89
Thailand	0	13	16
Vietnam	0	17	89
Irrigated area as percentage of planted area, end of period			
Bangladesh	5	13	32
India	37	42	50
Myanmar	14	18	30
Philippines	30	48	65
Thailand	26	23	20
Vietnam	–	41	52

Sources of information or data: production structure, trade structure; prices: discussion in text; yield: FAOStat on-line electronic database (2002); modern variety adoption, irrigated area: IRRI World Rice Statistics electronic database (2001); a dash (–) indicates data not available.

Trends in the level and stability of Asian rice production

Trends in the level of per capita production

Trends in the level and stability of Asian rice production go a long way toward explaining the trends in world rice prices noted above. The most striking example is that the plunge in world prices from 1982 to 1984 coincided with a sharp increase in per capita rice production in Asia (Fig. 2). During those 3 years, per capita production reached a new level of roughly 160 kg paddy (104 kg milled rice) per capita, and this level has been approximately maintained ever since. The proximate cause of the price decline was the achievement of rice self-sufficiency by Indonesia in 1984, which in the decade prior to that was by far the world's largest rice importer. From 1981 to 1984, rice production in Indonesia increased 16% in a span of just 3

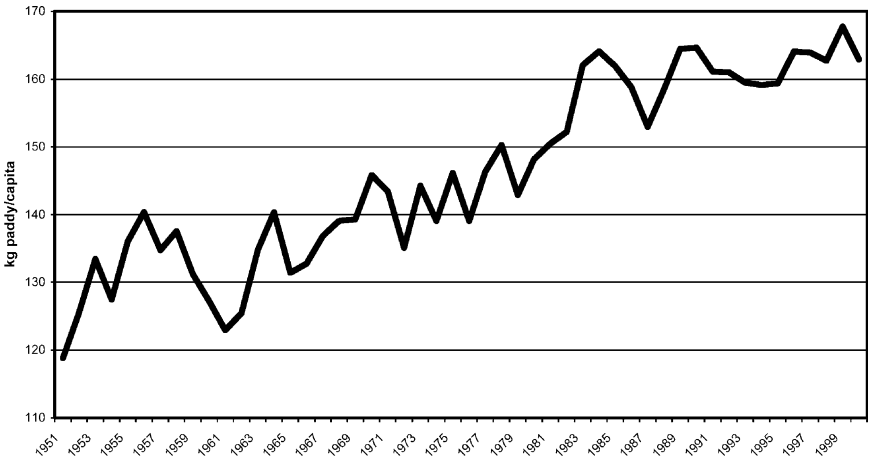

Fig. 2. Per capita Asian rice production, 1951–2000. Note: Asia includes the following 17 countries: Bangladesh, Cambodia, China, India, Indonesia, Japan, Korea (North), Korea (South), Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam.

years, and Indonesia's abrupt exit from the world rice market undoubtedly had both real and psychological effects on world prices. But, rice production surged in many other countries at this same time, and it was the combined growth in many countries that allowed world prices to stay at this new low level for the next 15 years, even when Indonesia returned to the world market in the 1990s. For example, production in China increased rapidly during this period due to the economic reforms begun in 1978 (Huang and Rozelle, 1996; Zhang and Carter, 1997). India and Vietnam also saw rapid surges in production during this time. These four countries are some of the world's leading rice producers, so the impact on Asian production was substantial (Table 3). At the same time that Asian rice production surged, the Thai baht was also devalued by nearly 25% during this time, from about 20.70 at the beginning of 1981 to about 27.10 by the end of 1984. The lower value of the baht raised the profitability of rice production in Thailand and exports surged from an average of 2.4 million ton during 1978–1980 to 4.4 million ton during 1984–1986.

Although the magnitude of the surge in per capita production from 1982 to 1984 was unprecedented, per capita production had been increasing steadily during the previous three decades. Why did these increases not have a similar depressing effect on world prices? The most likely reason is that Asian countries were much poorer in this earlier period, which meant that the income elasticity of demand for rice was still positive (Timmer et al., 1983). Thus, growth in rice production had to keep pace not only with population growth, but also with income growth. In other words, increased per capita production was necessary to keep world prices constant in real terms. As per capita incomes in Asia reached higher levels, however, the income elasticity of demand for rice declined to zero in many countries, and even became negative for some. This is reflected in declining trends in per capita rice consumption for Japan, South Korea, Malaysia and Thailand. In China, Indonesia, and the Philip-

Table 3
Leading rice producing countries, selected periods, with average level of production during each period (in millions of tons of paddy)

Country	1950–1964	1965–1981	1985–1998
China	73.5	120.4	184.8
India	44.8	64.7	111.1
Indonesia	11.3	21.3	45.5
Bangladesh	12.6	17.6	26.1
Vietnam	7.6	10.3	21.3
Thailand	9.3	14.3	20.5
Myanmar	6.4	9.2	15.4
Japan	14.2	16.0	12.9
Brazil	4.2	7.5	9.7
Philippines	3.4	5.8	9.7
Korea	4.0	6.2	7.4
World	215.0	331.0	521.6
As percent of world total (%):			
Top 5	73	73	75
Top 10	87	87	88

Sources of raw data: Palacpac (1977) for 1950–1960, FAOStat on-line electronic database (2002) for 1961–1998.

pines, per capita consumption has been approximately constant for at least the past decade. Thus, constant levels of per capita rice production are now sufficient to keep prices constant in real terms. This is consistent with the IMPACT model of the International Food Policy Research Institute (IFPRI), which projects that world rice prices will remain constant provided production growth roughly equals population growth between now and 2020 (Rosegrant et al., 1995).

While trends in per capita rice production explain to some extent the sharp drop in prices from the early to mid-1980s, this is probably not the whole story. World market prices for wheat and maize also declined sharply in the 1980s, as did many other commodity prices. In the case of maize, prices declined substantially even though world production growth slowed substantially in the 1980s. Pindyck and Rotemberg (1990) found evidence for excess co-movement of several commodity prices, even after accounting for the effects of macroeconomic variables, and a similar phenomenon may occur for rice, wheat, and maize. Yet rice prices declined more than wheat and maize prices during this period. Comparing the periods 1957–1981 and 1982–2000, the average ratio of rice to maize prices was 18% lower in the latter period, while the ratio of rice to wheat prices declined by 25%. These declines in the ratios of rice prices to prices for other grains suggest an important role for the surge in per capita rice production.

Trends in the stability of per capita production

At the same time that the level of per capita production has increased during the past half-century, it has also become more stable. The magnitude of year to year

fluctuations in per capita production has been markedly lower in the past 15 years than it was previously (Table 4). Prior to 1985, fluctuations in per capita production of >±3% were relatively common, occurring 22 times in the 29 years from 1952 to 1980. Since then, fluctuations of this magnitude have occurred just four times in 20 years. The average absolute value of annual changes in per capita production was 4.4% from 1952 to 1964, 3.7% from 1965 to 1981, and just 1.6% from 1985 to 1998. Other measures show a similar pattern.

This improvement in the stability of per capita production is most likely due to two major technological influences, irrigation and pest control. In the initial phases of the Green Revolution, irrigated area expanded rapidly due to large government investments (Barker et al., 1985). This growth slowed substantially in the 1980s as world rice prices declined (Hayami and Kikuchi, 1978). Furthermore, at the same time that lower rice prices reduced the benefits of constructing new irrigation systems, the cost of irrigation projects began to rise as the easiest areas to irrigate had already been exploited (Rosegrant and Svendsen, 1993). Despite these factors, however, the proportion of rice grown under irrigated conditions was higher in the mid-1990s than in the early 1980s (Huke and Huke, 1997). Part of this increase in the share of irrigated area in total area was due to the absolute decline in rice area planted in marginal ecosystems such as deepwater and upland. The area planted to deepwater and upland rice declined by more than 4 million ha between the early 1980s and mid-1990s, a fall of 25%. Reliable supplies of water have substantially reduced production fluctuations relative to a situation where production relies solely on the vagaries of rainfall.

Production stability has been further enhanced by the development of modern rice varieties that have become progressively more resistant to pests and diseases. The first modern high yielding semi-dwarf variety, IR8, suffered frequent attacks by diseases and insect pests. IR36 was released in 1976, and this new variety incorporated resistance to multiple pests and diseases. It was so successful that it is still grown in many areas today. Other derivative varieties (such as IR64) also incorporated much of this resistance, and this has proved to be a successful approach for stabilizing yields (Khush, 1995). Pesticide use has also increased over time, although it is not clear that use of these chemicals has always been successful in reducing crop losses.

Table 4
Stability of Asian per capita rice production

Period	Average absolute value of annual changes (%)	RMSE (from regression of per capita production vs. time trend) normalized by average per capita production
1951–1964	4.4	0.047
1965–1981	3.7	0.025
1985–1998	1.6	0.020

Sources of raw data: FAO (2002) for 1961–1998, Palacpac (1977) for 1951–1960. Time periods do not correspond exactly to those in Table 1 because of incomplete data on production for 1950.

To summarize, both the level and the stability of per capita rice production in Asia have increased substantially over time, and these developments would appear to explain why world prices have been so low and stable for the past 15 years. Yet, this cannot be the whole story. Why were world rice prices relatively stable from 1950 to 1964 in spite of very unstable production?

The fall and rise of commercially oriented rice exporters

An active world market: 1950–1964

For most of the 20th century, the major rice exporters in the world market have been the nations of mainland Southeast Asia: Thailand, Burma, Cambodia, and South (or southern) Vietnam. During the 1950s, Burma and Thailand dominated world rice exports, with Cambodia also being an important player (Table 5). More important, exports were a large share of domestic production for all of these countries (Fig. 3). From 1950 to 1963, the average share of exports in domestic production was 40% in Burma, 32% in Cambodia, and 24% in Thailand. South Vietnam was also a net exporter in the 1950s, but its total exports were roughly only one-third of Cambodia's, and its share of exports in domestic production was also quite low.

During this period, agriculture dominated the economy of these poor countries, and rice dominated the agricultural sector. Furthermore, because a large share of production was exported to world markets, these countries needed to be commercially oriented and participate actively in the world rice market as reliable suppliers.[2] Not only was rice an important share of the economy, but it was also a key source of foreign exchange earnings and government revenue. For example, in Thailand taxes on rice exports consistently accounted for more than 10% of all government revenue in the years 1950–1965, and the share occasionally reached more than 25% (Siamwalla, 1975). Thus, whenever there was a shortfall in Asian rice production, one or more of these countries would typically step in to fill the breach and prevent world prices from spiraling out of control. For example, there were large declines in per capita production in 1954 and 1957 (due to a major La Niña event in 1954/1955 and a major El Niño event in 1957/1958; NOAA, 2000). To meet the shortfall in 1954, Burma stepped into the market and exported a then record of 1.7 million tons, followed by another record of 2.0 million tons in 1955. In these 2 years, its share of exports in domestic production surged to 49%, relative to an average of just 33% in the preceding 3 years.

In 1957, Asian per capita production fell by 4%. Aggravating matters, production dropped sharply in the two major exporters, by 15% in Burma and 33% in Thailand. Nevertheless, these two countries responded. Exports from Burma fell compared to

[2] The phrase 'commercial orientation' may have different meanings and may be difficult to measure. For the purposes of this paper, a commercially oriented rice exporter is defined as an exporter with a relatively high ratio of exports to domestic production, as this indicates that a relatively high level of attention must be given to marketing supplies to international customers.

Table 5
Leading rice exporting and importing countries, selected periods, with average annual level of exports/imports during each period (in millions of tons of milled rice)

Country	1950–1964	Country	1965–1981	Country	1985–1998
Exports					
Myanmar	1.52	USA	2.03	Thailand	5.12
Thailand	1.38	Thailand	1.75	USA	2.55
USA	0.80	China	1.62	Vietnam	1.60
China	0.69	Myanmar	0.59	India	1.42
Cambodia	0.47	Pakistan	0.58	Pakistan	1.29
Egypt	0.22	Italy	0.34	China	1.10
Italy	0.19	Egypt	0.32	Italy	0.61
Vietnam	0.16	Japan	0.30	Australia	0.47
Pakistan	0.12	Australia	0.18	Uruguay	0.39
Brazil	0.06	North Korea	0.17	Myanmar	0.29
World	6.05	World	9.23	World	16.72
As percent of world total (%):					
Top 5	80		71		72
Top 10	93		85		89
Imports					
Indonesia	0.70	Indonesia	1.02	Iran	0.77
Japan	0.66	Vietnam	0.62	Indonesia	0.75
India	0.58	South Korea	0.51	Brazil	0.68
Malaysia and Singapore	0.53	India	0.42	Saudi Arabia	0.47
Sri Lanka	0.47	USSR	0.40	China	0.47
Hong Kong	0.31	Hong Kong	0.36	USSR/CIS	0.47
East Pakistan	0.25	Sri Lanka	0.35	Iraq	0.46
Cuba	0.20	Bangladesh	0.31	Philippines	0.42
West Germany	0.13	Malaysia	0.29	Malaysia	0.40
Philippines	0.11	Singapore	0.24	Senegal	0.40
World	6.10	World	9.30	World	16.05
As percent of world total (%):					
Top 5	48		32		20
Top 10	65		49		33

Sources of raw data: Palacpac (1977) for 1950–1960, FAOStat on-line electronic database (2002) for 1961–1998. World exports and imports are not equal in any particular year in original data sources. USSR is not included in 1950–1964 imports because of data availability constraints.

the record high of the previous year, but they still reached 43% of domestic production in spite of the production shortfall. Thailand enacted quantitative restrictions at this time (Siamwalla, 1975), but they were not very severe in their effect as exports hit a near record of 1.5 million tons, with 40% of production being sent to the world market. As a result of exports from these two countries, world prices barely budged from the mid- to late 1950s.

Another major shortfall in per capita production occurred from 1959 to 1961, but this was primarily due to the policies of the Great Leap Forward in China that led to a dramatic collapse of production. Because of China's isolation at that time, it

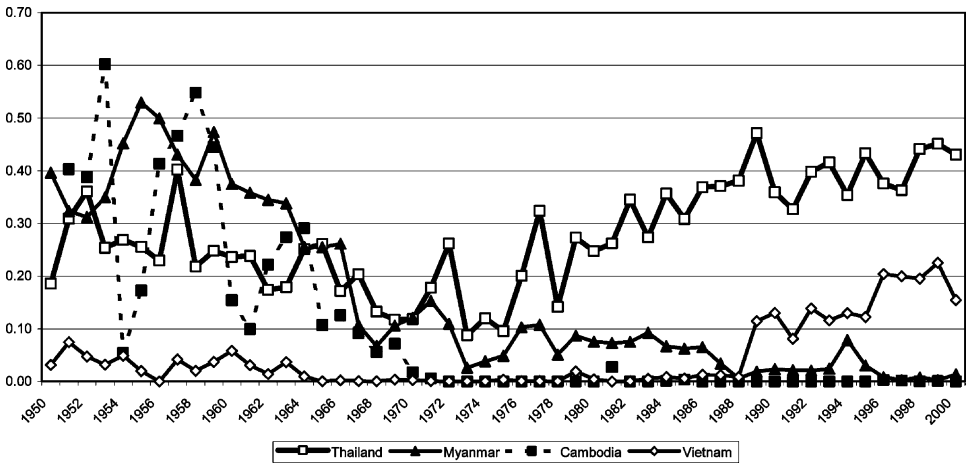

Fig. 3. Ratio of exports to domestic production, 1950–2000: Thailand, Myanmar, Cambodia, and Vietnam.

did not enter world markets to try and make up the deficit with increased imports. Again, world prices did not increase substantially.

Exit of the exporters: 1965–1981

The situation had changed considerably by the mid-1960s, when a major El Niño event led to a sharp fall of 6% in per capita Asian production in 1965. By this time, Burma, the leading rice exporter in the 1950s, was well into a period of sharp decline due to the restrictive policies of General Ne Win, who had seized power in a coup in 1962. Exports were falling, and by 1967, they had declined to just 11% of domestic production (Fig. 3) as world prices surged 30%. The proportion of Cambodia's production that found its way onto world markets was also in a period of decline (Fig. 3). South Vietnam banned exports in 1965, and it did not return to the world market as an exporter until the late 1980s. Perhaps more surprisingly, even Thailand was becoming less commercially oriented. By 1967, revenue from rice export taxes had fallen to just 6% of total government revenues, and this declined to just 1% by 1971 (Siamwalla, 1975). Since the government was no longer so reliant on export tax revenue, it had more flexibility to constrain exports in the interests of domestic price stabilization. As a result, during the world price spike in 1967, Thailand raised its rice premium (a form of export tax) to levels more than double than that of its previous high.

By the early 1970s, the world market was even more unsettled. The proximate cause of the world food crisis of 1973–1975 was a severe El Niño in 1972–1973, followed by major La Niña events in 1973–1974 and 1975–1976. But this situation was exacerbated considerably by the behavior of the traditional commercial rice exporters. Thailand's exports fell to just 10% of domestic production from 1973 to 1975, reaching their lowest point in the post-war period, and it banned exports com-

pletely for a few months in 1973 (Slayton, 1999). By this time, Cambodia had joined South Vietnam and completely exited the market, while Burma was also out for all practical purposes (Fig. 3). The situation was so difficult for countries wishing to import rice that the experience of this period continues to shape policies and attitudes in the region to the present day.

Re-emergence of market stabilizers: 1985–2000

By the middle to late 1980s, this situation had changed considerably for the better. Thailand's commercial orientation has increased steadily since the world food crisis, with exports now typically accounting for 40% of domestic production. Vietnam has re-entered the world rice market, with exports accounting for approximately 20% of domestic production during the past 5 years. The presence of Thailand and Vietnam as commercially oriented rice exporters was a major factor in stabilizing the world market in 1998 in the face of a major El Niño event that led to a fall in per capita Asian rice production. Thai exports surged to a record of 6.4 million tons, while exports from Vietnam jumped to 3.8 million tons. The devaluation of the Thai baht played an important role in spurring exports, but Fig. 3 shows that Thailand is also now much more commercially oriented compared to the mid-1970s. This is reflected in current Thai policy, which now allows free trade in rice even if the consequence is increased domestic prices (i.e. export taxes have been abolished). During the recent financial crisis, domestic rice prices in Thailand rose by more than 50% in real terms between November 1997 and January 1998. Despite this rapid rise, the government allowed domestic prices to track world prices one for one. This is an important policy change that adds considerably to the stability of the world market.

Myanmar and Cambodia are yet to return to the world market to play a major role. Especially in Myanmar, more liberal domestic policies would increase domestic production and exports substantially. Nevertheless, other exporters have emerged to complement Thailand and Vietnam. The share of exports in production in Pakistan has steadily increased during the past two decades, and is now typically 40%. China and India have also emerged as important exporters in recent years. Although the vast majority of rice production in the world's two largest countries is consumed domestically, both have proved able to export large quantities in recent years. India was the world's second largest exporter (behind only Thailand) in 1996 and 1998, exporting more than 5 million tons in 1998. China exported more than 3.5 million tons in 1998. The apparent willingness of these countries to supply world markets lends added stability in times of crisis.[3]

The renewed presence of several commercially oriented rice exporters is reflected in the share of world rice production that is traded on world markets. Between 1961 and 1993, world trade fluctuated between 3.5 and 5% of world production (on average, it was 4.3%). Since 1994, however, the ratio has exceeded 5% every single

[3] Although the US is also a major exporter, most US rice is too expensive to enter the Asian trade on a purely commercial basis.

year, and the share traded has averaged 6.1%. This does not make the world rice market as heavily traded as world wheat and maize markets, but it still represents an important increase. Furthermore, although the world rice market is less heavily traded than other grain markets, world rice prices are now more stable than world wheat and maize prices, in contrast to earlier periods (Table 6). Thus, while world market price stability has improved for all three major grains, it has improved most for rice.

Whither the world rice market?

The recent plunge in world prices

What does the future hold for the world rice market, in terms of the level and stability of prices? In terms of levels, prices have declined substantially in the past 3 years. From 1998 to 2001, the price of 100Bs (the highest quality rice of those that are widely traded) fell 48% in real terms. The price of 25% brokens, a quality roughly equivalent to what is eaten by average consumers in major importing countries such as Indonesia and Philippines, declined by a similar amount.

The magnitude of this decline is nearly equivalent to the precipitous decline that occurred from the early to mid-1980s, and the reasons behind it are similar as well. First, after importing 6 million ton in 1998, Indonesia greatly reduced its exposure to the world market in succeeding years. The reasons were different this time (a recovery in production from the El Niño drought, a depreciation of the exchange rate, and a tariff on rice as opposed to a production surge caused by new technology and infrastructure), but the consequences were the same: lower world prices. Second, the Thai baht was devalued during the Asian financial crisis. Third, rice production has surged recently in Bangladesh, Vietnam, Pakistan, and India. From 1995 to 1999 (just 4 years), production surged 30, 26, 30, and 15% in these four large countries, respectively. Much of this recent surge was underpinned by public and private invest-

Table 6
Comparative stability of world grain markets

Commodity	1957–1964	1965–1981	1985–1998
Average absolute value of annual percentage price changes (%)			
Maize	5	12	15
Wheat	4	16	15
Rice	7	24	11
RMSE (from regression of real price vs. time trend) normalized by average price			
Maize	0.068	0.222	0.155
Wheat	0.066	0.284	0.147
Rice	0.065	0.341	0.111

Source of raw data: IMF (2002). Time periods do not correspond exactly to those in Table 1 because shorter time-series of prices are available for wheat and maize than for rice.

ments in water control. For example, the proportion of irrigated area in Bangladesh was just 25% in the early 1990s, but it is now more than half due to the expansion of private sector shallow tubewell irrigation. Vietnam has recently invested heavily in constructing sluice gates to control salinization and new canal systems to increase rice area in the Mekong Delta.

A simple structural model of world rice prices

The similarity of events surrounding the two large price declines of the past 20 years suggests the possibility of isolating the contributions of each factor through the use of a multiple regression model (Table 7). The model was estimated in both levels and first differences. The results were similar for both, but only the results for the level specification are presented.[4] The price series used was for 25% brokens because this is the most common quality imported by the two main Asian developing country importers, Indonesia and Philippines. (Similar results were also obtained with the price series for 100Bs, the highest grade of *indica* rice on the world market.) The time period covered by the analysis was 1984–2000. Earlier data were not used because the structure of the world market was different before 1984, as argued above.

Explanatory variables included 1 and 2 year lags of per capita production, a 1 year lag of the logarithm of the nominal Thai baht versus US$ exchange rate, and Indonesian imports. (A measure of the real exchange rate of the baht versus the US$ was also used, with similar results. Time trends were included in both the level and first difference specifications, but were not significant.) Since population growth is the main source of demand growth in the Asian rice economy, production was normalized by population, i.e. per capita rice production was used as the independent

Table 7
Coefficient estimates from structural model of real world rice prices

Variable	Coefficient estimate	Standard error	*t*-Statistic	*p*-Value
Constant	3331	411	8.11	0.00
PCP(-1)	–6.73	2.31	–2.91	0.01
PCP(-2)	–7.47	2.20	–3.40	0.01
lnBahtUS$(-1)	–222	64	–3.45	0.01
IndonImports	8.56	5.33	1.61	0.13

Estimation uses annual data from 1984 to 2000 (FAO, 2002; IMF, 2002; USDA, 2000). Dependent variable is real price (25% brokens). PCP is per capita rice production for an aggregate of 17 large Asian countries (see note to Fig. 2). lnBahtUS$ is the natural logarithm of the Thai baht/US$ exchange rate. IndonImports is net rice imports by Indonesia. Number of observations=17; R^2 = 0.86; adjusted R^2 = 0.81; DW statistic=1.31.

[4] Dickey–Fuller tests indicate that the null hypothesis of a unit root for real prices cannot be rejected, but weighted symmetric (τ) tests indicate that real prices are I(0). Since τ tests dominate Dickey–Fuller tests in terms of power (Pantula et al., 1994), the level specification is reported in the text.

variable. This normalization keeps the demand curve fixed and allows estimation without resorting to a system of simultaneous equations. Net trade in rice for Asia is a very small percentage of total production.

Thailand is the world's largest exporter and Indonesia the world's largest rice importer, justifying the use of important economic variables from these two countries. Policy and structural differences between the two countries account for the different manner in which the Indonesia and Thailand variables enter the model. First, Indonesian imports were hypothesized to have a contemporaneous effect on world prices, while the value of the Thai baht was hypothesized to affect the world price with a 1-year lag. This is because import demand can increase world prices in a very short term, while changes in production incentives for Thai farmers transmitted through the exchange rate require time before farmers can adjust planting decisions. Also, during the past 20 years, private sector rice exports from Thailand have been largely unrestricted. Thus, export quantities are endogenous to world prices and it is necessary to use the value of the Thai baht instead of exports in order to have the independent variable be exogenous. On the other hand, net Indonesian imports are used because import and export decisions were under monopoly control of the Indonesian government until very recently and were made in response to domestic needs, not the level of the world price. Thus, Indonesian imports are effectively exogenous to world prices.

All estimated coefficients are of the expected sign and have relatively low *p*-values, although the coefficient on Indonesian imports is not statistically significant at conventional levels. Furthermore, the model captures turning points in prices over the interval quite well. The magnitude of the coefficient estimate for the variable measuring net Indonesian imports implies that an increase in Indonesian imports of 1 million tons is associated with an increase in world prices of US$8.56 per ton, other things being equal. The magnitude of the coefficient on the value of the Thai baht implies that a depreciation of the baht by 10% in year t is associated with a decline in world prices of US$22 per ton in year $(t + 1)$. The coefficients on the two lags of per capita production imply that an increase in per capita production of 1 kg paddy per capita in year t is associated with a decline in prices of US$6.73 per ton in year $(t + 1)$ and a further US$7.47 per ton in year $(t + 2)$. (Current per capita production is approximately 165 kg paddy per capita.)

The future of the world rice market and policy implications

If this model is at least approximately true, it would imply that prices will remain in the neighborhood of their current low levels for the medium term, barring a large fall in per capita rice production, a major appreciation of the Thai baht, or Indonesia becoming an important exporter. The latter two alternatives seem unlikely, and there are no concrete signs of per capita production falling from current near record levels. The one possible countervailing factor is the long-term slowdown in yield growth that has occurred throughout Asia. This phenomenon has been most pronounced in countries like Indonesia and Philippines that were among the first to embrace the modern varieties of the Green Revolution (Otsuka, 2000). In both of these countries,

rice yields are no higher today than they were 10 years ago. If yield growth continues to decelerate throughout Asia, and does so faster than population growth, then per capita production will probably begin to decline and this may cause rice prices to rise.

Furthermore, it seems likely that world prices will generally remain stable in the near future, just as they have during the past 15 years. The improvement in stability has come about due to the greater importance of irrigation in rice production, the improved pest and disease resistance of modern varieties, and the re-emergence and strengthening of the commercial orientation of major rice exporting nations. None of these trends are likely to be reversed. Although the growth of irrigation is slowing in Asia, the share of irrigated land in total rice area is still increasing (albeit slowly). Plant breeders continue to improve the insect and disease resistance of modern varieties, and biotechnology holds out hope for even more improvements in this area. Finally, as the world economy moves toward freer trade and increasing integration, it is unlikely that Thailand and Vietnam will turn their back on the world rice market. And with appropriate changes in policies, Myanmar and Cambodia may emerge to become important stabilizing forces once again sometime in the next decade.

Reduced price variability does not necessarily mean that the effects of instability are now entirely negligible. Price fluctuations still cause serious problems for many poor Asians, and the resultant effects on producer and consumer welfare can have political repercussions. And, even if the world rice market is relatively quiet in the future, increased financial market liberalization may lead to greater exchange rate fluctuations in the future (Stiglitz, 2000). Under free trade, changes in exchange rates translate to changes in domestic rice prices just as much as changes in world rice prices, and Asian governments will need to formulate cost-effective policies to deal with these issues (Dawe, 2001). Nevertheless, it seems likely that the combination of low and stable prices on the international market will continue for the medium term. This suggests that there is less risk if rice importing countries decide to rely on the world market more heavily than they have in the past.

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