

International Trade and Risk Sharing in the Global Rice Market: The Impact of Foreign and Domestic Supply Shocks

SHIKHA JHA, KENSUKE KUBO, AND BHARAT RAMASWAMI*

In the first decade of this millennium, rising food prices returned as a concern for policy makers, especially in developing economies. This paper examines how supply shocks, both domestic and foreign, impacted imports and consumption in the world rice market between 1960 and 2010. Such an investigation is important in assessing the role of trade in compensating for domestic shocks. If shortages lead economies to impose trade restrictions, then trade may not be allowed to play an important role in stabilizing consumption. The existing literature has highlighted the importance of these policy shocks in the world rice market and how they have worked to increase the volatility of prices and trade flows. Although trade cannot be expected to play a strong role when the major producing and consuming economies are simultaneously hit by negative yield shocks, such a scenario has occurred in only about 3% of all observed cases. We also find that consumption fails to stabilize even when domestic shocks are negative and foreign shocks are positive; however, imports do peak. Thus, while trade does help in coping with domestic risks, it is unable to achieve full risk sharing. Therefore, no matter the nature of foreign shocks, the principal concern is to stabilize consumption when an economy is hit by negative domestic yield shocks. The frequency of such shocks is about 12% in all observed cases, highlighting the importance of domestic responses. We find that domestic rice stocks have been important in stabilizing consumption. The reliance on domestic policies has, in turn, kept the rice market thin.

Keywords: food prices, international trade, rice market, risk sharing, supply shocks

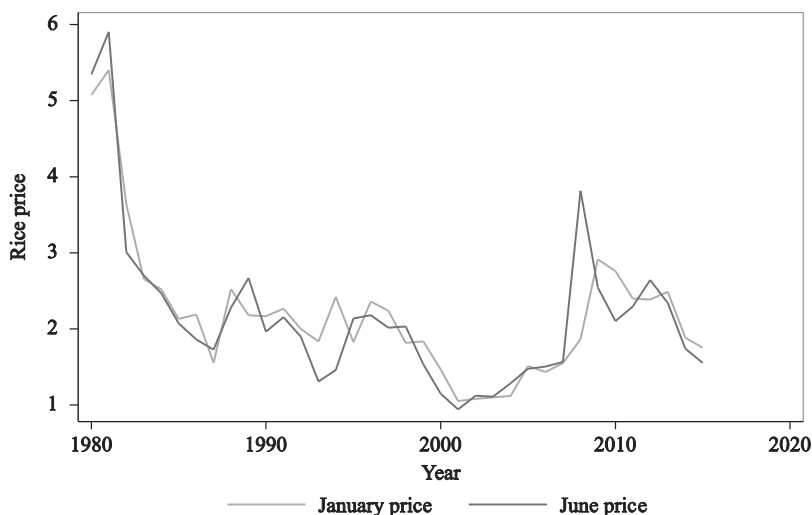
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I. Introduction

Early in the 21st century, an old concern resurfaced—that of rising food prices. After the food crisis in the mid-1970s, the world enjoyed declining to stable

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Figure 1. **World Rice Prices, 1980–2015**
(\$ per ton)



Notes: Monthly prices are deflated by the United States Consumer Price Index sourced from the Bureau of Labor Statistics. January prices refer to the prices prevailing in January; June prices refer to the prices prevailing in June. Source: International Monetary Fund. Primary Commodity Prices. <http://www.imf.org/external/np/res/commod/index.aspx>

real prices until the mid-1990s. In 1995–1996, there was a spike in prices followed by a return to the long-term trend. From the early part of the 2000s, however, prices began creeping upward, culminating in sharp rises between 2006–2007 and 2008–2009.

Palm oil, rice, and wheat prices doubled between 1999–2000 and 2007–2008, while maize and soybean prices increased by more than 75% over the same period (Gilbert 2011).¹ What was striking was that the price spikes happened in a very short time interval. In nominal terms, world maize prices increased by 54% from August 2006 to February 2007. This was followed by an increase in world wheat prices of 125% from May 2007 to March 2008. The most dramatic increase occurred in rice prices. From April 2001 to September 2007, a gradual upward drift saw the price of Thai 100% B rice double from \$170 per ton to \$335 per ton, amounting to a 67% increase relative to the United States (US) Consumer Price Index. Between October 2007 and April 2008, the price tripled again to over \$1,000 per ton (Dawe and Slayton 2011). These trends are evident in Figure 1, which plots rice prices deflated by the US consumer price index for the period 1980–2015.

The food price spikes of 2007–2008 renewed old debates about the efficacy and desirability of price stabilization measures. Economists have long argued that storage-based price stabilization is expensive and, in some instances, ineffective. On

¹Gilbert (2011) reports these price changes after deflating the nominal prices by the US Producer Price Index.

the other hand, opening up the economy to trade can be effective in insulating against severe domestic shocks. The food price crisis of 2007–2008, however, planted doubts in the minds of policy makers about the reliability of world markets in times of need. Several policy studies have concluded that some public grain reserves are necessary. Price stabilization pursued through public stocks cannot be effective, however, when borders are open. Therefore, some restriction of trade is also necessary.

Within the context of this debate, the goal of this paper is to examine how supply shocks, both domestic and foreign, have impacted imports and consumption in the global rice market between 1960 and 2010. In autarkic economies, domestic supply shocks drive consumption shocks as well. In economies open to trade, and when trade functions well, domestic consumption depends on both domestic and foreign supply shocks. Compared to autarky, domestic shocks matter less because of access to world markets. For small open economies, domestic shocks should not matter at all.

These ideal outcomes may not be obtained, however, if policies impede trade. Rising prices often provoke governments to put in place policies that buffer the impacts. When these policies take the form of trade restrictions, world trade may shrink; thus, economies might not have access to world supplies to compensate for adverse domestic shocks. Rice is commonly considered the archetype of an agricultural staple that is subject to such endogenous policy shocks. Hence, we chose to study the impact of domestic and foreign supply shocks on rice imports and consumption.

The structure of this paper is as follows. The next two sections offer a selective survey of the literature on the global rice market with respect to endogenous policy shocks and the reliability of the rice trade. Section IV is a descriptive account of the global rice trade and the trade interventions of major exporters. Section V offers a statistical analysis of the impact of exogenous domestic and foreign supply shocks on imports and consumption. Section VI extends this to include the policy variable of domestic and foreign stocks. Concluding remarks comprise section VII.

II. The Rice Market and Endogenous Shocks

The role of policy responses in provoking and exaggerating price spikes has been evident in the global rice market. A review of the literature reveals that the rice market is particularly subject to endogenous policy shocks. Unlike wheat and maize, a relatively small proportion of world rice production (about 9%) is traded internationally. Moreover, the wheat and maize trade is driven by surpluses from rich and large land-abundant economies such as Argentina, Australia, Canada, and the US. In the case of wheat, Australia, Canada, and the US export more than 50% of their production. The biggest rice exporter, Thailand, exports close to 40% of its output. However, its share in world rice output is less than 5% of the total. Meanwhile, India is emerging as a strong competitor to Thailand, vying for the

position of the top exporter. Yet, in 2014–2015, despite a record increase amounting to a little over one-fifth of world production, India exported barely 10% of its output. By offloading its huge stockpile, India could become the swing actor in the world rice market.

Apart from India, other large rice-producing economies such as Bangladesh, the People's Republic of China (PRC), and Indonesia are either deficient in production, or at best, have small surpluses relative to consumption. All of these economies have poor populations that are severely affected when rice prices rise. Due to such food security concerns, these economies will likely reduce their net supply to the world market in times of crisis. This can take the form of export restrictions or reductions in import tariffs. Following a self-sufficiency approach, much of Asia is stockpiling rice as well. In either case, the attempts of these economies to increase their share of world consumption can raise world prices. Thus, policies directed toward insulating domestic markets magnify international price volatility when all economies attempt to insulate their respective domestic markets at the same time (Abbot 2011, Martin and Anderson 2011).

During the crisis of 2007–2008, many scholars argued that it was likely that the spike in rice prices was due not to crop failure or low stocks but to policy measures put in place by panicked governments. As early as October 2008, Timmer (2008) argued that the underlying causes for the rise in rice prices were different from those for wheat and maize prices. Low stocks, crop failures, and financial speculation were not plausible factors behind the price increases in rice in 2007–2008. Nor could these increases be attributed in a straightforward manner to the rise in wheat or maize prices because substitution in consumption among these grains is limited. Rather, Timmer contended, the spike must be seen as being due to export restrictions by some of the major exporting economies, which induced panic buying by importers, such as the Philippines, and a storage-driven approach because of the hoarding instincts of governments and other agents. This sentiment has been echoed by others (Dawe and Slayton 2011, Gilbert and Morgan 2010, Wright 2011).

Martin and Anderson (2011) estimate that more than 45% of the explained change in international rice prices during 2005–2008 was due to export restrictions (compared with 29% for wheat). Using a global economywide model, Jensen and Anderson (2014) estimate the impact of such price-insulating policies to be about one-third of the world price rise. If anything, these estimates are surprising in that endogenous shocks account for only one-third to one-half of the rice price increase when most of the literature seems to argue that increases are significantly driven by policy shocks. The hypothesis that export policies contribute to global price volatility has also been tested by Giordani, Rocha, and Ruta (2012). Using a dataset on trade measures relating to the food sector, they found that the probability that an economy imposes a new export restriction is positively associated with global restrictions on the product (i.e., the share of international trade covered by export restrictions). For 2008–2010, they estimate that a 1% surge in the share of trade

covered by export restrictions is associated with a 1.1% increase in international food prices.

III. The Reliability of the Rice Trade and Rice Markets

In an integrated global market, trade provides a means for price stabilization without costly investment in commodity stocks. This has been the view of many economists. However, this does not take into account the possibility of government intervention such as market-insulating policies. If exporters fearing a shortfall restrict their supply, importers are deprived of food just when they need it the most. Such an experience can persuade importers that the food trade is unreliable and that they should increase self-sufficiency by investing in domestic stocks and raising production irrespective of the costs.

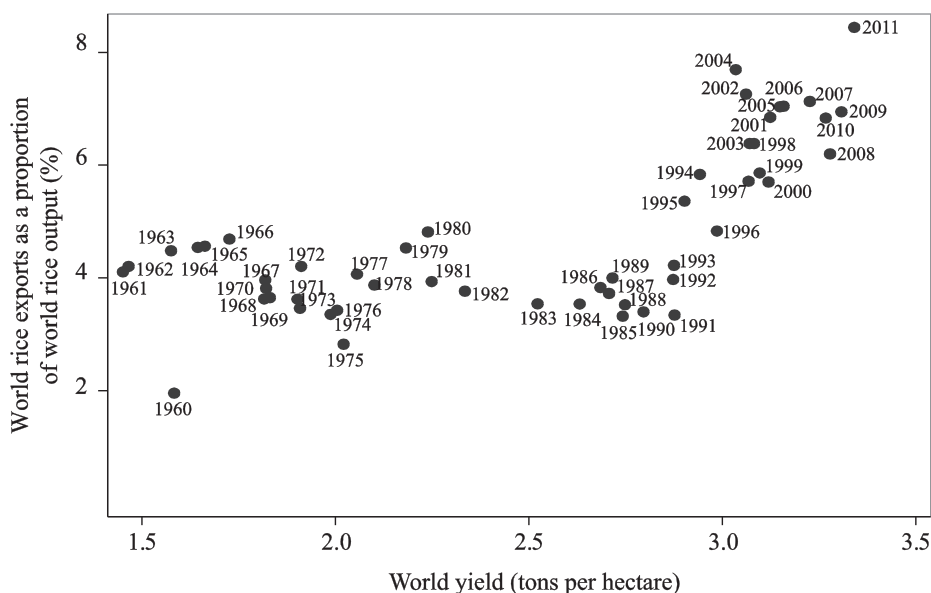
Gilbert (2011) argues that rice trade and rice markets are the most unreliable among those of the major grains. In an earlier work (Gilbert 2010), he showed that a commonly quoted world rice price—the spot price in Bangkok—follows various national prices rather than the other way around (as it is for maize). Given that the rice market “functions least well,” Gilbert (2011) argues for a pragmatic approach in which it is recognized that low-income economies “can probably rely on being able to import additional maize or wheat if this proves necessary, but may justifiably be worried about being able to do so for rice.” Further, he argues, “[T]his points towards the need for contingency arrangements for rice—either food security stocks, or formal trade agreements with rice exporters or, where this is feasible, a move towards rice self-sufficiency.”

A related point is that the rice market has been seen to be somewhat disconnected from the markets for other cereals. Shocks to rice supply and demand are not highly correlated with those of other grains. Global futures markets are irrelevant to rice and the crop is not used as a biofuel (Dawe and Slayton 2011). It is in this sense that Gilbert and Morgan (2010) regard the rice price spike in 2007–2008 as “peculiar and in some sense pre-modern.” Unlike that of other grains, the price volatility in the rice market does not always depend on the fundamentals of demand and supply shocks and price elasticities. The particular problem of the rice market is the tendency of important trading economies to shield themselves from external shocks. Hence, “rice is different” and the future course of volatility will depend on how the international community addresses the particular problems of this market (Gilbert and Morgan 2010).

IV. Global Rice Trade

Imagine a two-economy trade model in which one of the economies is producing rice. Imagine also that there is no government intervention in either

Figure 2. World Rice Trade and World Yields



Source: Authors' estimates.

Table 1. World Export-to-Output Ratios
(in percentages)

	1960–1993	1994–2011
Mean	3.82	7.16
Standard deviation	0.56	2.14
Coefficient of variation (%)	14.66	29.89

Source: Authors' estimates.

exports or imports. The production of rice is subject to stochastic yield shocks. It is expected that the higher the yield, the greater the volume of rice that is traded. Figure 2 plots the proportion of world output that is exported against world yields for 1960–2011. The world yield is the production share weighted average of individual economy yields. For world yields up to 3 tons per hectare (ha), world exports fluctuate at around 4% of world output without any trend. Beyond that, in the range of 3–3.5 tons per ha, the ratio of exports to world output fluctuates at a higher level of around 7%. A closer look shows that the observations in the right half of Figure 2, involving world yields of more than 3 tons per ha, belong to the period beginning in 1994.

Table 1 shows that the average export–output ratio in 1994–2011 was 7.2%—which represents an increase of 87% over the average value in the pre-1994 period. The discrete jump in the export–output ratio is primarily due to increased rice exports from India. Until the early 1990s, quantitative restrictions clamped down on

nonbasmati rice exports from India. The removal of these restrictions in 1993–1994 led to nonbasmati rice exports of 4.5 million tons from less than 1 million tons in the early 1990s (Kubo 2011). The other factor behind the higher export–output ratio in 1994–2011 is the rise of Viet Nam as a major rice exporter. This has been a more gradual process that started with the economy’s reentry into the world market in 1989. Therefore, export liberalization in India and Viet Nam, which are the next leading exporters after Thailand, explains why the world rice market grew relatively thicker in the 1990s.

It could, however, be argued that a common trend may be responsible for the correlation between world yield and the export–output ratio. Indeed, if the export–output ratio is regressed on world yield and a time trend (whether linear or quadratic), the coefficient of world yield, while still significant, becomes negative. While this means that deviations from the trend are negatively correlated, the presence of a common trend is suggestive of the positive association between the two variables.

In Table 1, the pre-1994 period is characterized by low variability in the export–output ratio even as yields doubled, while the post-1994 period is characterized by high variability in the export–output ratio even as yields remained in a narrow range of 3–3.5 tons per ha. The coefficient of variation of the export–output ratio in 1994–2011 is twice that in the pre-1994 period. Thus, it seems that while world markets have been more open since the 1990s, policy interventions have made them more unstable as well.² It could be that limited reforms and a longer period of time allowed for developing (*vis-à-vis* developed) economies to meet their market access commitments generated by the Uruguay Round helped these countries stabilize domestic prices even as world prices became more volatile. Wailes (2005) reports coefficients of variation of domestic rice prices of 26% for Indonesia, 37% for the PRC, and 43% for India over the 15–20 years prior to 2005. Much of the trade expansion during that period was on account of the surging rice imports of Asian and African economies that was supported by abundant supplies in major exporting economies (Calpe 2006). However, following the food price crisis, India and Viet Nam were among the first economies to impose export restrictions in 2007 as both have domestic concerns with impacts that spill over into international markets. This was evident even prior to the 2007–2008 crisis.

In India, the principal domestic policy imperative is for the government to procure enough supplies to maintain its distribution channels of subsidized rice and wheat. A failure to restrict procurement left India with an accumulation of massive stocks in 2001 amounting to 51 million tons of grain, including 25 million tons of rice. This prompted the government to sell the grain at subsidized prices for

²Higher variability in the export–output ratio could also be because of greater yield instability. However, this does not appear to be the case. While mean world yields increase from 2.16 tons per ha in the first period to a little over 3 tons per ha in the second period, the coefficient of variation drops from 21% to 7.4% between the periods.

export. Global price effects were thus a byproduct of domestic food security policy in India, a large rice trader (Jha 2012). The subsequent unloading of stocks in the international market led to rising exports and the prolonged stagnation of rice prices in the global market (Kubo 2011). Such large-scale dumping of government stocks on the world market ceased after 2004. By 2005, rice stocks in India had fallen to 13 million tons and, more significantly, wheat stocks had dropped to 2 million tons. A subsequent shortfall in wheat procurement that coincided with wheat crop failures in the rest of the world panicked the Indian government into wheat imports and a determination not to allow similar shortfalls in rice procurement. So after dumping rice stocks on the world market in the early 2000s, the government moved to restrict and finally ban rice exports in the late 2000s. With the recovery of rice and wheat stocks, the government eventually lifted export restrictions.

Viet Nam has always maintained tight control over rice exports. Initially this took the form of export quotas for registered companies. These were later abolished and the government now suspends rice exports once the total reaches a targeted level. In 2007, this happened routinely. In 2008, faced with rising domestic prices, the government did not allow new export contracts until July of that year. As in India, concern over the domestic availability of rice prompted the government to tightly monitor export volumes. However, there is a difference as well: India's exports are less than 5% of its consumption; in Viet Nam, they amount to more than 30% of its consumption. Therefore, global rice sales are more important for Viet Nam's economy and government regulations have been more predictable and more sensitive to the interests of exporters.

V. The Impact of Exogenous Shocks on Imports and Consumption

A systematic relationship between world yields and the global rice trade is not evident in Figure 2. Within a two-economy model, it would be realistic to assume that both economies produce rice. In a model of free trade, the amount of rice traded depends on both domestic yield shocks and foreign shocks. For instance, it is expected that importing economies decrease imports in response to positive domestic yield shocks and increase imports when there is a positive yield shock in a foreign economy. As imports feed into consumption, we can also consider the consequences for this indicator of economic welfare. For both economies in the model, consumption is expected to be positively related to both domestic and foreign yield shocks. In the extreme and unrealistic case of perfectly integrated markets, the source of the yield shock would not matter. A weaker hypothesis is that consumption depends positively on both domestic and foreign yield shocks. We now test these hypotheses.

Our dataset on an economy's production, area, and stocks is drawn from the US Department of Agriculture. To compute exogenous shocks, we smooth the

Table 2. **Cross-Tabulation of Foreign and Domestic Yield Shocks—All Economies**

Domestic Shock	Foreign Yield Shock			Total
	Negative High	Mid-Range	Positive High	
Negative High	116 2.72	311 7.31	88 2.07	515 12.10
Mid-Range	533 12.52	2,111 49.59	550 12.92	3,194 75.03
Positive High	9 2.21	363 8.53	91 2.14	548 12.87
Total	743 17.45	2,785 65.42	729 17.12	4,257 100.00

Note: Values in the lower row represent the number of cross-tabulated observations as a proportion of all observations.

Source: Authors' estimates.

yield series using the Holt–Winters double exponential method. The deviation of the smoothed series from the observation is defined as the yield shock. This is computed for every economy. For every economy, we also compute a foreign yield shock, which is the production weighted average of the yield shocks in each of the economies constituting the rest of the world.

To examine the potential of trade, the correlation between domestic yield and foreign yield shocks is worth considering. When there are adverse shocks to both domestic and foreign yields, trade cannot be of much help. To assess the probability of such outcomes, we slice domestic and foreign yield shocks into three categories: (i) a high negative shock, when the shock is one standard deviation below the mean; (ii) a high positive shock, when the shock is one standard deviation above the mean; and (iii) a mid-range shock, when the yield deviation is within one standard deviation of the mean. This is done for every economy and for every year in the sample. The cross-tabulation of these shocks for all economies in the sample is displayed in Table 2. Table 3 contains these cross-tabulations for the major economies that make up world rice production and trade: Bangladesh, the PRC, India, Indonesia, Iran, Malaysia, Nigeria, Pakistan, the Philippines, Saudi Arabia, Thailand, Viet Nam, and the US.

The results show that in only about 3% of the cases for the entire sample and in about 1% of the cases for the major economies, low domestic yields are accompanied by low foreign yields as well. This means that except for these instances trade, in principle, should work well in the overwhelming majority of circumstances when domestic production shortfalls are offset to some extent by higher output elsewhere, and vice versa. Yet the puzzle is that the rice trade is considered unreliable relative to other grains.

Table 4 is a regression of the first difference in log of imports (as a proportion of consumption) on the dummy variables for each of the categories in the cross-tabulations of Tables 2 and 3. The regression is based on the sample of all

Table 3. **Cross-Tabulation of Foreign and Domestic Yield Shocks—Major Economies**

Domestic Shock	Foreign Yield Shock			Total
	Negative High	Mid-Range	Positive High	
Negative High	10 1.48	56 8.30	19 2.81	85 12.59
Mid-Range	91 13.48	334 49.48	76 11.26	501 74.22
Positive High	22 3.26	49 7.26	18 2.67	89 13.19
Total	123 18.22	439 65.04	113 16.74	675 100.00

Notes: Major economies comprise the following major importing and exporting economies: Bangladesh, the People's Republic of China, India, Indonesia, Iran, Malaysia, Nigeria, Pakistan, the Philippines, Saudi Arabia, Thailand, the United States, and Viet Nam. Values in the lower row represent the number of cross-tabulated observations as a proportion of all observations.

Source: Authors' estimates.

Table 4. **Imports Regression—Dependent Variable: First Difference of Log (Imports/Consumption)**

Variable	Coefficient	Standard Error	t-value
Dummy variable for negative domestic yield shock and negative foreign yield shock	0.398	0.131	3.03
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	0.286	0.113	2.52
Dummy variable for negative domestic yield shock and positive foreign yield shock	0.636	0.141	4.51
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	0.139	0.108	1.29
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	0.182	0.102	1.78
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	0.112	0.109	1.03
Dummy variable for positive domestic yield shock and negative foreign yield shock	-0.316	0.139	-2.28
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	0.057	0.112	0.51
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)		
Constant	-0.181	0.100	-1.80

Notes:

1. The number of observations is 2,683.
2. The sample of importing economies is for 1960–2010.
3. Regression model includes economy fixed effects.

Source: Authors' estimates.

importing economies. As expected, the percentage change in imports is negative and the greatest in absolute value when the domestic shock is highly positive and the foreign shock is highly negative. This is the case when the demand for imports

is at its minimum and the world supply is also at its lowest. Unsurprisingly, the percentage change in imports is positive and maximal when the domestic shock is highly negative and when the foreign shock is highly positive. This is the opposite case when world supply and demand for imports are at their maximum. These are instances when trade works in the expected direction. More surprisingly, imports as a proportion of consumption increase even when shocks are negative at home and abroad. In this case, world supply is low but import demand is high. For example, Indonesia imported exceptionally high volumes of rice in 1997 and 1998 to mitigate the impacts of El Niño. Similarly, the food price crisis of 2007–2008 led the Philippines to import rice at exorbitant prices in a panic-buying spree. Rice is the single most important food in these two economies, comprising almost one-half of the calorie intake in each.

There is a clear pattern to the results. The percentage change in imports is less (or negative) when domestic shocks are highly positive; it is high and positive when domestic shocks are highly negative.

To see the cost of highly negative domestic shocks, consider a regression of the log change in rice consumption as a function of the dummy variables representing the combination of highly negative, mid-range and highly positive domestic and foreign yield shocks. Table 5 shows the results for the entire sample of economies, not just importers. A second specification in the table adds lagged values of the dependent variable as regressors.³ The impact of the shocks does not vary much between the specifications in terms of the sign and significance of the coefficients.

Reading from the first specification, rice consumption declines by 9% in the scenario of highly negative domestic and foreign yield shocks.⁴ In the scenario of highly negative domestic shocks and highly positive foreign yield shocks, rice consumption declines by 4.5%. The difference in outcomes between these scenarios is a measure of the value of access to world markets. However, consumption declines in all of the scenarios involving negative domestic yield shocks. Positive foreign shocks can compensate, but not fully. Earlier, we mentioned that a reliance on trade could fail in about 2% of the instances when negative shocks affect both domestic and foreign markets. But now it is apparent that rice consumption is vulnerable in all scenarios involving negative domestic shocks. Such instances occur about 12%

³Conventional fixed-effects estimators (e.g., within estimator) are inconsistent when lagged values of the dependent variable are used as regressors. We used the Arellano–Bond estimator which transforms the data into first differences and takes care of the correlation between the error term (first difference of the original error term) and the lagged first differences of the dependent variable by using higher-order lags of the dependent variable as instrumental variables (Arellano and Bond 1991).

⁴This is the sum of the constant term and the coefficient of the dummy variable for highly negative domestic and foreign yield shocks. All regressions have an economy-specific fixed effect. As it is additive, it nets out when considering the difference between the base and omitted category of positive domestic and foreign yield shocks and the other categories.

Table 5. **Consumption Regression, All Economies—Dependent Variable: Log of Change in Rice Consumption**

Variable	Standard			Standard		
	Coefficient	Error	t-value	Coefficient	Error	t-value
Dummy variable for negative domestic yield shock and negative foreign yield shock	-0.222	0.032	-6.94	-0.219	0.042	-5.26
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	-0.186	0.027	-6.80	-0.195	0.045	-4.37
Dummy variable for negative domestic yield shock and positive foreign yield shock	-0.176	0.034	-5.10	-0.188	0.054	-3.49
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	-0.107	0.026	-4.10	-0.103	0.038	-2.71
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	-0.092	0.025	-3.74	-0.088	0.041	-2.18
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	-0.107	0.026	-4.11	-0.103	0.044	-2.35
Dummy variable for positive domestic yield shock and negative foreign yield shock	-0.006	0.034	-0.19	-0.027	0.046	-0.59
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	-0.025	0.027	-0.92	-0.024	0.045	-0.53
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)			(omitted)		
Lagged dependent variable (first order)				-0.344	0.033	-10.30
Lagged dependent variable (second order)				-0.117	0.033	-3.55
Constant	0.131	0.024	5.44	0.141	0.039	3.60

Notes:

1. The number of observations is 4,155 (3,885 for specification with lagged dependent variables).
2. The sample consists of 87 economies for 1960–2010.
3. Regression model includes economy fixed effects.
4. The specification with lagged dependent variables has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.

Source: Authors' estimates.

of the time. Perhaps this is why rice markets are regarded as unreliable by policy makers.

The flip side of these results is that rice consumption increases by about 10%–13% in all scenarios involving positive domestic shocks. Most strikingly, the increase in consumption in the scenario of positive domestic and foreign yield shocks (13%) is almost the same as in the scenario of positive domestic and negative foreign yield shocks (12.5%). The failure of trade to redistribute supplies in the

Table 6. Consumption Regression, Selected Asian Economies—Dependent Variable: Log of Change in Rice Consumption

Variable	Standard			Standard		
	Coefficient	Error	t-value	Coefficient	Error	t-value
Dummy variable for negative domestic yield shock and negative foreign yield shock	-0.169	0.034	-4.92	-0.185	0.010	-18.64
Dummy variable for negative domestic yield shock and mid-range foreign yield shock	-0.078	0.022	-3.52	-0.088	0.040	-2.21
Dummy variable for negative domestic yield shock and positive foreign yield shock	-0.106	0.025	-4.16	-0.119	0.041	-2.89
Dummy variable for mid-range domestic yield shock and negative foreign yield shock	-0.050	0.021	-2.34	-0.057	0.030	-1.93
Dummy variable for mid-range domestic yield shock and mid-range foreign yield shock	-0.046	0.020	-2.27	-0.052	0.027	-1.91
Dummy variable for mid-range domestic yield shock and positive foreign yield shock	-0.033	0.022	-1.54	-0.041	0.024	-1.70
Dummy variable for positive domestic yield shock and negative foreign yield shock	-0.002	0.025	-0.09	-0.016	0.020	-0.81
Dummy variable for positive domestic yield shock and mid-range foreign yield shock	0.017	0.022	0.77	0.000	0.027	0.00
Dummy variable for positive domestic yield shock and positive foreign yield shock	(omitted)			(omitted)		
Lagged dependent variable (first order)				-0.235	0.102	-2.31
Lagged dependent variable (second order)				-0.144	0.085	-1.70
Constant	0.068	0.020	3.43	0.087	0.028	3.13

Notes:

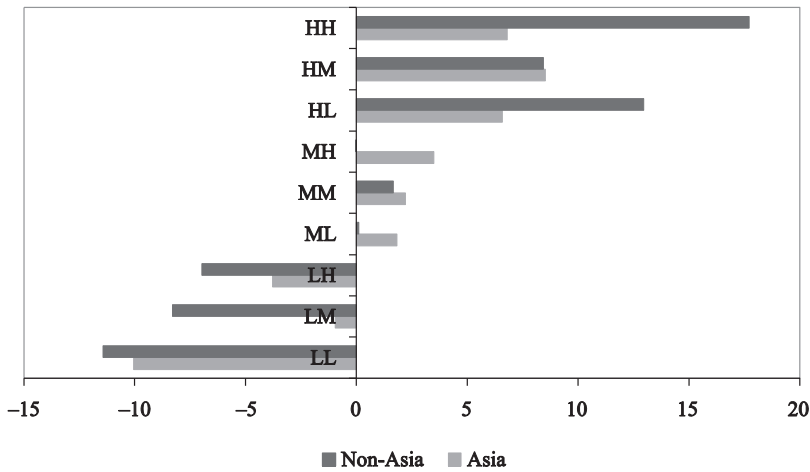
1. The number of observations is 306 (288 for specification with lagged dependent variables).
2. The sample consists of six economies for 1960–2010: Bangladesh, the People's Republic of China, India, Indonesia, the Philippines, and Viet Nam.
3. The regression uses economy fixed effects.
4. The specification with lagged dependent variables has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.

Source: Authors' estimates.

latter scenario seems to be the reason why trade is not able to stabilize consumption in economies hit by negative domestic shocks even when world supplies are ample.

Table 6 is the consumption regression for some of the Asian economies that are important in the world rice economy: Bangladesh, the PRC, India, Indonesia,

Figure 3. Percentage Change in Rice Consumption—Asian versus Non-Asian Economies



Notes: Each scenario is denoted as XY, where the domestic shock $X = \{H, M, L\}$ and the foreign shock $Y = \{H, M, L\}$. H, M, and L represent the positive, mid-range, and negative shocks, respectively.

Source: Authors' estimates.

the Philippines, and Viet Nam. Pakistan and Thailand are excluded.⁵ Once again, the implied rates of consumption change do not vary greatly between the two specifications.

Figure 3 compares the average percentage change in rice consumption in each of the shock scenarios for the Asian sample and for all other economies in the sample. Each scenario is denoted as XY, where the domestic shock $X = \{H, M, L\}$ and the foreign shock $Y = \{H, M, L\}$; and H, M, and L represent the positive, mid-range, and negative shocks, respectively. The horizontal bars represent the percentage change in rice consumption in each of the nine scenarios. For instance, the bars at HH show that when domestic and foreign yield shocks are both positive, average rice consumption in Asia increases by about 7%, while average consumption in non-Asian economies increases by more than 15%. The percentage changes are derived from Table 6 and a similar regression for the non-Asian economies that is not reported here.⁶ In both of these regressions, the base category is the HH scenario and therefore the percentage change here is given by the coefficients of this category in the regressions. For the other scenarios, the coefficient of each category is added to the coefficient of the dummy for the HH category to obtain the percentage change in consumption.

The common finding is that rice consumption declines are substantial and comparable in the scenarios of negative domestic and foreign shocks. However,

⁵Exports as a proportion of consumption are greater than 50% in both Pakistan and Thailand. The vulnerability of domestic consumption to yield shocks is not a major concern here.

⁶Results are based on coefficient estimates for the specification that does not include lagged values of the dependent variable as regressors.

Asian economies seem to do better in arresting consumption declines in scenarios involving negative domestic yields. The most striking difference involves the positive domestic yield scenarios: consumption growth in the Asian economies is lower than in the world sample. This could be due to either exports or the buildup of domestic stocks. The latter seems more likely because, as in the world sample, the difference in consumption growth between the scenarios of positive and negative foreign shocks (given a positive domestic shock) is small. Domestic stocks, in turn, may have enabled these economies to stabilize consumption when domestic shocks are negative. Yet, even this policy has not been successful when negative domestic shocks are accompanied by negative foreign shocks. Another possible explanation for consumption smoothing could be unregulated rice trading and smuggling in Asian economies such as the PRC, Indonesia, Kazakhstan, Myanmar, the Philippines, Thailand, and Viet Nam (Chen 2008, Mon 2015).

VI. Policy Response

Negative domestic shocks occur when stabilization fails to take place. Access to world markets helps, but consumption declines even when foreign yields are high. These are reduced form results based on the outcome of both trade and domestic stabilization policies. To understand how trade and domestic policies modify exogenous shocks, we consider the following regression model for economy j and year t :

$$\ln \left(\frac{C_{jt}}{C_{j,t-1}} \right) = \beta_1 + \beta_{2jt}DY_{jt} + \beta_{3jt}FY_{jt} + \beta_4DS_{jt} + \beta_5FS_{jt} + \theta_j + \varepsilon_{jt} \quad (1)$$

where C is rice consumption; DY and FY are domestic and foreign yield shocks, respectively; DS and FS are the domestic and rest-of-the-world stocks, both as proportions of domestic and rest-of-the-world consumption, respectively, at the beginning of year t ; and θ_j is an economy fixed effect. Earlier, we explained how shocks were constructed.

In our data, the policy variable is the level of stocks in each economy.⁷ Clearly, trade restrictions will have a direct impact on stocks. For each economy, we construct a domestic stock variable and a foreign stock, which is an aggregate of stocks in the rest of the world. We allow the coefficients of domestic and foreign yield shocks to vary with domestic stocks and foreign stocks:

$$\beta_{2jt} = \gamma_1 + \gamma_2DS_{jt} + \gamma_3FS_{jt} \quad (2)$$

⁷The reliability of stocks data is open to question. This caveat applies to the empirical analysis that follows.

Table 7. Consumption Regression with Yield Shocks and Stocks—Dependent Variable: Log of Change in Rice Consumption

Variable	Coefficient	Standard	
		Error	t-value
Lagged dependent variable (first order)	-0.341	0.033	-10.39
Lagged dependent variable (second order)	-0.127	0.030	-4.25
Domestic stock/Consumption	0.293	0.096	3.05
Foreign stock/Foreign consumption	0.243	0.247	0.98
Domestic yield shock	0.195	0.079	2.46
Foreign yield shock	0.234	0.671	0.35
Domestic shock × (Domestic stock/Domestic consumption)	-0.095	0.040	-2.39
Domestic shock × (Foreign stock/Foreign consumption)	0.115	0.298	0.39
Foreign shock × (Domestic stock/Domestic consumption)	-0.697	0.363	-1.92
Foreign shock × (Foreign stock/Foreign consumption)	-0.052	2.832	-0.02
Constant	-0.058	0.060	-0.98

Notes:

1. The number of observations is 3,885 for 87 economies.

2. The regression uses economy fixed effects.

3. The model has been estimated with the Arellano–Bond method using second- to sixth-order lags of the dependent variable as instrumental variables.

Source: Authors' estimates.

and similarly,

$$\beta_{3jt} = \delta_1 + \delta_2 DS_{jt} + \delta_3 FS_{jt} \quad (3)$$

Based on our previous findings, we expect the coefficient of domestic yield, γ_1 , to be positive. We also expect the coefficient of foreign yield, δ_1 , to be positive but not as large as γ_1 . Since domestic stocks are expected to soften the effect of yield shocks, the coefficients γ_2 and δ_2 are expected to be negative. Domestic stocks are also likely to have a direct positive impact on consumption; hence, we expect a positive sign for β_4 . It is not clear a priori how the level of foreign stocks might affect domestic consumption, either directly or indirectly, by impacting how yield shocks affect consumption.

The results are presented in Table 7. Both domestic shocks and domestic stocks have a positive impact on the change in consumption and are statistically significant. Foreign yields and foreign stocks are not significant. The interaction term involving domestic shocks and domestic stocks is significantly negative. This shows that domestic policies moderate the impacts of domestic shocks.

An alternative specification replaces both shock variables by the dummies representing negative, mid-range, and positive shocks as defined earlier. Both sets of dummies are interacted with domestic and foreign stocks. This allows policies to interact with shocks in a nonlinear manner. This specification is estimated in Table 8. The omitted base category in the table is the combination of mid-range domestic and mid-range foreign yield shocks.

Table 8. Consumption Regression with Yield Shocks and Stocks—Dependent Variable: Log of Change in Rice Consumption

Variable	Coefficient	Standard Error	t-value
Lagged dependent variable (first order)	-0.338	0.032	-10.53
Lagged dependent variable (second order)	-0.119	0.030	-3.99
Domestic stock/Consumption	0.272	0.087	3.12
Foreign stock/Foreign consumption	0.253	0.289	0.88
Negative domestic shock	-0.145	0.039	-3.75
Negative domestic shock × (Domestic stock/Consumption)	0.093	0.043	2.14
Negative domestic shock × (Foreign stock/Foreign consumption)	0.124	0.127	0.97
Positive domestic shock	0.050	0.047	1.04
Positive domestic shock × (Domestic stock/Consumption)	-0.096	0.046	-2.10
Positive domestic shock × (Foreign stock/Consumption)	0.150	0.172	0.88
Negative foreign shock	-0.009	0.035	-0.26
Negative foreign shock × (Domestic stock/Consumption)	0.071	0.059	1.21
Negative foreign shock × (Foreign stock/Foreign consumption)	-0.050	0.140	-0.36
Positive foreign shock	0.044	0.031	1.40
Positive foreign shock × (Domestic stock/Consumption)	-0.010	0.033	-0.29
Positive foreign shock × (Foreign stock/Foreign consumption)	-0.236	0.136	-1.73
Constant	-0.054	0.070	-0.76

Notes:

1. The number of observations is 3,885 for 87 economies.
2. The regression uses economy fixed effects.
3. The model has been estimated with the Arellano–Bond method using second- to eighth-order lags of the dependent variable as instrumental variables.

Source: Authors' estimates.

Like in the previous specification, foreign stock is not significant either by itself or when interacted with shocks. Relative to the base category, the decline in the growth of rice consumption in the event of a negative domestic shock is $0.272DS + 0.253FS + (-0.145 + 0.093DS + 0.124FS)$, where DS and FS are domestic and foreign stock ratios, respectively. The coefficients of both stock variables (in their interaction with negative domestic shock) are positive, suggesting that stocks—domestic and foreign—help in moderating the decline in rice consumption. However, the interaction of a negative domestic shock with foreign stock is not significant. Neither is the foreign stock coefficient by itself.

On the other hand, the domestic stock variable is significant in itself and in its interaction with a negative domestic shock. The combined effect is $0.365DS$. The median value of domestic stocks as a proportion of consumption is 0.05. This means that its contribution in reducing the hit on consumption is about 1.8 percentage points. The 75-percentile level of stocks is 0.2. At this level, stocks would arrest the decline in consumption by 7.3 percentage points. Domestic stocks would have to be about 40% of consumption to wipe out the 14.5% decline in rice consumption (relative to base category) that is due to negative domestic shocks. Thus, while domestic stabilization policies through grain reserves have moderated consumption declines, their contribution at the median level of stocks is limited.

VII. Concluding Remarks

There is considerable literature about world price volatility and the transmission of world prices to domestic prices. In this paper, we have taken a different route to assess stability and examine the role of trade and domestic stabilization policies. For each economy, we constructed exogenous domestic and foreign (i.e., rest of the world) yield shocks and looked at their impacts on rice imports and rice consumption. We also considered how these impacts were modified by domestic and foreign stocks.

If supply shocks are uncorrelated across economies, the global supply is essentially stable. Provided that there are no demand shocks, the global price is also stable. Importing economies would be able to import whenever they need to and at a stable price. Even if shocks are correlated across economies, as long as the correlation coefficient is less than 1, the global aggregate supply is much more stable than individual economy supplies.

Although trade cannot be expected to play a strong role when the major producing and consuming economies are simultaneously hit by negative yield shocks, such a scenario occurs in only about 3% of observed cases. In all other cases of negative domestic shocks, they can be at least partially neutralized by positive foreign shocks. This implies that in a world of free trade, consumption levels in individual economies would be stabilized. However, our study finds that this is not the case. In cases of adverse domestic shocks, consumption fails to be stabilized even when foreign shocks are positive; however, imports do peak. Thus, while trade does help in coping with domestic risks, it is unable to achieve full risk sharing. The flip side is that when domestic yield shocks are positive, consumption surges even when the shock in the rest of the world is negative.⁸ Therefore, irrespective of foreign shocks, the principal concern for poor economies is to stabilize consumption when hit by negative domestic yield shocks. The frequency of such shocks is about 12%.

Domestic policies have played a greater role in stabilizing the adverse impacts of negative shocks. This could be because of the presumed unreliability of the rice trade. Storage is expensive, however, and economies often follow ad hoc rules of thumb and tend to carry too much stock either because of extreme precaution or because these policies have been captured by producer interests (Gilbert 2011, Knudsen and Nash 1990).⁹ A judicious combination of stocks and trade can be an effective tool to stabilize domestic prices, but at the cost of higher global price volatility (Gouel and Jean 2015). Otherwise, reliance on domestic stabilization will continue to keep rice markets thin and promote market insulation policies similar to those that led to the rice price spike in 2007–2008.

⁸As a referee points out, this could be a statistical artifact since changes in private stocks are not measured and are therefore included in consumption.

⁹For a review of the Indian experience, see Ramaswami and Murugkar (2013).

Cooperative solutions such as common food reserves could also serve as the region's insurance in times of food crises. Toward this end, the Association of Southeast Asian Nations (ASEAN) has made progress in adopting a framework to set aside and share rice stocks for contingencies. ASEAN includes some of the world's largest importers (Indonesia and the Philippines) and exporters (Thailand and Viet Nam), as well as Myanmar, which is aspiring to regain its status of the 1950s as the world's largest exporter of rice. While contingency stocks may be a good initiative to address crises in individual economies, they are inadequate to deal with crises of regional proportions. To succeed, the region must establish a mechanism to mobilize collective action and cooperation, especially when a shock affects multiple economies simultaneously (Jha and Rhee 2012).

A positive development in the world rice market is the greater volume of trade achieved since the mid-1990s due to export liberalization in India and the entry of Viet Nam into world markets. Can there be another shift upward? Surpluses in commercial rice-exporting economies such as Thailand, Pakistan, and the US are already high. Exports are as high as domestic consumption in Thailand and Pakistan, while in the US, the ratio is close to 60%. That is why the thickening of the rice market had to depend on new exporters such as India and Viet Nam.

Between 2006 and 2008, Viet Nam's exports were consistently around 21% of consumption. However, Indian exports have varied between 2.5% and 6% of domestic consumption. Not only has India's contribution to world exports varied, but its surpluses have also been small relative to domestic consumption. Negative domestic shocks and domestic policies can shrink these surpluses quickly. Similarly, in other large rice-producing economies such as Bangladesh, the PRC, and Indonesia, the surpluses or deficits are small relative to consumption. It is not clear whether these economies can be reliable contributors to global supplies in the future. In addition, climate change poses unknown perils to some of the major rice growing regions in Bangladesh and India.

In this sense, the rise of Viet Nam is reassuring to the long-term future of the world rice market, although its surpluses are not as large as in Thailand. While surpluses may continue to rise in Viet Nam, especially with rising prosperity, the emergence of surpluses in other economies might be needed for the rice market to thicken. Myanmar and Cambodia are possible candidates for exporting rice. As the PRC becomes a net importer, low-income economies in the Greater Mekong Subregion in Southeast Asia hold significant potential to increase productivity and contribute to dramatic regional trade expansion (Jha et al. 2010). But this can only be realized if policies are integrated and complementary.

High and volatile global prices can generate panicked herd behavior. Experience shows that antitrade bias in agricultural policies, such as price-insulating export restrictions and aggressive importations, contribute significantly to world price increases. Historically, food price volatility has been higher when trade has been impeded (e.g., during the two world wars, the breakdown of Bretton Woods

in the 1970s, and the global food price crisis in 2007–2008). Restoring confidence in the food trade is the key, but binding economies to agree multilaterally to limit trade restrictions—though plausible—does not seem feasible at present. Regional or bilateral agreements among Asian economies, which produce and consume over 90% of the world’s rice, could perhaps be the starting point. However, even within ASEAN, progress in cooperation remains limited despite the great potential for raising productivity, production, and food security.

While it may seem that a more reliable rice-trading system would have to await greater productivity increases in some of the key rice-producing regions of the world, developing economies are also seeing a major paradigm shift in social safety net policies. The emphasis has shifted from commodity subsidies and market interventions to cash transfers. The shift in these policies is made possible by continuing developments in information and communication technologies. It is plausible that these trends may lead developing economies to de-emphasize grain stocks, which in turn could lead the rice trade to grow. However, as grain prices matter to the value of cash transfers, they will continue to be a high priority on the economic and political agenda of developing economies.

References

- Abbot, P. C. 2011. Export Restrictions as Stabilization Responses to Food Crisis. *American Journal of Agricultural Economics* 94 (2): 428–34.
- Arellano, M., and S. Bond. 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economics Studies* 58 (2): 277–97.
- Calpe, C. 2006. Rice International Commodity Profile. Rome: Food and Agricultural Organization of the United Nations.
- Chen, S.-C. 2008. A Black Market Grows in Rice. *Forbes*. 5 January.
- Dawe, D., and T. Slayton. 2011. The World Rice Market in 2007–08. In A. Prakash, ed. *Safeguarding Food Security in Volatile Global Markets*, pp. 164–82. Rome: Food and Agriculture Organization of the United Nations.
- Gilbert, C. L. 2010. Food Prices in Six Developing Economies and the Grains Price Spike. Paper presented at Danish Institute for International Studies Workshop on Impacts, Responses, and Initial Lessons of the Financial Crisis for Low-Income Economies. *Copenhagen*. 14–15 October.
- . 2011. Food Reserves in Developing Economies: Trade Policy Options for Improved Food Security. Issues Paper No. 37. Geneva: International Centre for Trade and Sustainable Development.
- Gilbert, C. L., and C. W. Morgan. 2010. Food Price Volatility. *Philosophical Transactions of the Royal Society B* 365 (1554): 3023–34.
- Giordani, P. E., N. Rocha, and M. Ruta. 2012. Food Prices and the Multiplier Effect of Export Policy. Staff Working Paper ERSD 2012–08. Geneva: World Trade Organization, Economic Research and Statistics Division.
- Gouel, C., and S. Jean. 2015. Optimal Food Price Stabilization in a Small Open Developing Country. *World Bank Economic Review* 29 (1): 72–101.

- Jensen, H. G., and K. Anderson. 2014. Grain Price Spikes and Beggar-Thy-Neighbor Policy Responses: A Global Economy-wide Analysis. Policy Research Working Paper 7007. Washington, DC: World Bank.
- Jha, S. 2012. Food Procurement Policy. In K. Basu and A. Maertens, eds. *The New Oxford Companion to Economics in India* (3rd edition), pp. 250–54. Delhi: Oxford University Press.
- Jha, S., and C. Rhee. 2012. Distributional Consequences and Policy Responses to Food Price Inflation in Developing Asia. In R. Arezki, C. Pattillo, M. Quintyn, and M. Zhu, eds. *Commodity Price Volatility and Inclusive Growth in Low-Income Economies*, pp. 277–95. Washington, DC: International Monetary Fund.
- Jha, S., D. Roland-Holst, S. Sriboonchitta, and D. Behnke. 2010. Regional Trade Opportunities for Asian Agriculture. In J. Gilbert, ed. *New Developments in Computable General Equilibrium Analysis of Trade Policy*, pp. 273–302. Bingley, United Kingdom: Emerald Group Publishing.
- Knudsen, O., and J. Nash. 1990. Domestic Price Stabilization Schemes in Developing Economies. *Economic Development and Cultural Change* 38 (3): 539–58.
- Kubo, K. 2011. India: The Burden of Domestic Policy. In S. Shigetomi, K. Kubo, and K. Tsukada, eds. *The World Food Crisis and the Strategies of Asian Rice Exporters: Spot Survey No. 32*. Chiba, Japan: Institute of Developing Economies.
- Martin W., and K. Anderson. 2011. Export Restrictions and Price Insulation during Commodity Price Booms. *American Journal of Agricultural Economics* 94 (2): 422–27.
- Mon, K. H. 2015. Smuggling across Borders with China,* Thailand Rising: Minister. *Irrawaddy*. 21 January.
- Ramaswami, B., and M. Murugkar. 2013. Food Policy Reforms, A Rapid Tour of Possibilities. South Asia Working Paper Series No. 18. Manila: Asian Development Bank.
- Timmer, C. P. 2008. Causes of High Food Prices. ADB Economics Working Paper Series No. 128. Manila: Asian Development Bank.
- Wailes, E. J. 2005. Rice: Global Trade, Protectionist Policies, and the Impact of Trade Liberalization. In M. Aksoy and J. Beghin, eds. *Global Agricultural Trade and Developing Economies*. Washington, DC: World Bank.
- Wright, B. 2011. The Economics of Grain Price Volatility. *Applied Economic Perspectives and Policy* 33 (2): 32–58.

*ADB recognizes “China” as the People’s Republic of China.