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Rice in Asia's Feed Markets

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James Hansen

Abstract

Historically, only humans—not livestock—consumed rice. Consequently, rice is considered a food grain and not a feed grain. However, the Food and Agriculture Organization of the United Nations estimates that in 2013 more than 33 million metric tons (mt) of rice were devoted to feed, with the amount growing by 0.5 million mt per year since 2003, an average annual growth rate of 1.7 percent. In several Asian countries, policies incentivized overplanting and boosted stocks, eventually leading governments to release rice from their stocks for feed use at a small fraction of the procurement cost. Thus far, South Korea, Japan, and Thailand have diverted rice into feed grain markets to reduce government stocks. China, the world's largest producer and consumer of rice, has near-record rice stock levels, and policymakers there could follow a similar path. This report discusses policies and consumption changes that have led to the increased use of rice for feed. It also uses the USDA, Economic Research Service baseline model to simulate the effect on corn and rice markets if China were to divert rice into its feed market.

Keywords: rice, Asia, rice consumption, rice stocks, rice imports, feed rations

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Rice in Asia's Feed Markets

Introduction

In Asia, rice is a staple food, holding both economic and cultural importance. During the 20th century, several Asian countries adopted policies to support and protect rice producers through subsidies, guaranteed prices, and barriers to imports. Objectives of these policies included stabilizing rice prices, reducing dependency on foreign supplies, increasing farm income, and improving nutrition among the poor (Barker et al., 1985).

As Asian countries have industrialized and urbanized, their diets have diversified away from rice as their staple food and toward new noncereal foods (Huang and David, 1993; Maclean et al., 2013). Research finds that following a certain income threshold, rice consumption per capita declines (Timmer and Alderman, 1979; Huang and David, 1993; Timmer et al., 2010). Meanwhile, as their domestic livestock sectors have increased, several countries in East Asia—including Japan, South Korea, and China—have adopted a strategy of importing feed grains to support their growing livestock operations. Similarly, Thailand, in Southeast Asia, uses imported feed for a large portion of its feed rations. These countries have thus become important in the global trade of grains and oilseeds.

The combination of rice-related government policies and declines in table (or food) rice consumption has contributed to high levels of government rice stocks in South Korea, Japan, Thailand, and China. One way to reduce surplus rice stocks is to divert stocks into alternative markets, including the livestock feed market. Globally, feed is the second largest use of rice, accounting for nearly 7 percent of use (fig. 1).¹ Livestock producers can substitute rice, a carbohydrate, for other cereal feed grains such as corn, sorghum, and wheat (see box, “Nutrition and Viability of Rice as a Feed Grain.”) Corn remains the most-utilized feed carbohydrate (fig. 2).

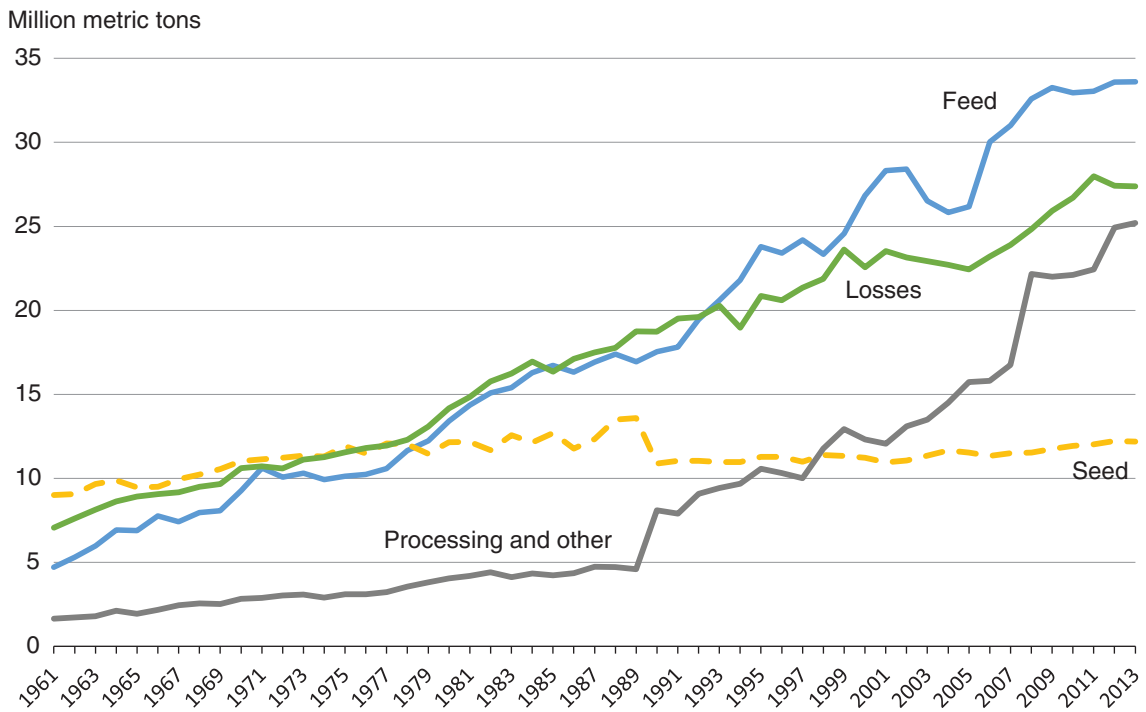
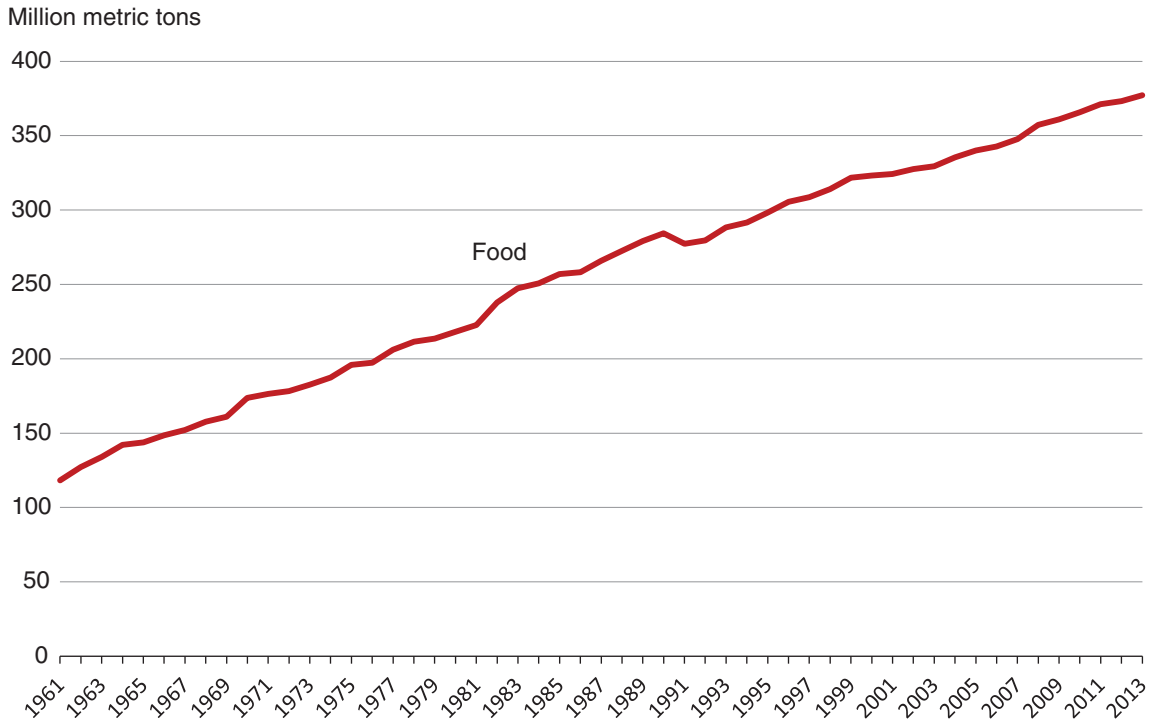
In this report, we examine rice-centric policies, decreases in rice consumption, rice stocks, the use of rice as a feed grain, and the effect of such use in South Korea, Japan, and Thailand. We also compare the situation in those countries with the rice outlook in China, where record levels of Government rice stocks have led that country's leaders to search for ways to reduce stocks. During the 2017 National Party Congress, industry leaders suggested using rice in ethanol production (Kim, 2018a). Such use has no precedent in China and indicates a major reversal in national food security policy and in the association of rice as a food-only grain (Kim, 2018b).

Taking into account the magnitude of current stocks in China and the possible adoption of rice as an ethanol feedstock, we present a simulated scenario in which China would follow the same path as Japan, South Korea, and Thailand and divert rice stocks to feed use.² Although rice prices are still above feed corn prices in China, corn prices have been surging upward and old-crop rice prices have moved downward. Therefore, producers may soon consider rice as an alternative livestock feed source (Kim, 2018b).

¹This figure includes use of rice byproducts, such as broken rice.

²China has consistently used a small share of rice for feed. According to the United Nations Food and Agriculture Organization, China uses about 10 percent of rice (including byproducts) for feed. However, it has not employed a policy of rice for feed as a means to decrease stocks.

Figure 1
Global uses of rice, 1961-2013



Source: United Nations, Food and Agriculture Organization.

Nutrition and Viability of Rice as a Feed Grain

Farmers use feed rations to supply the necessary nutrients (water, protein, carbohydrates, fats, and minerals) to their livestock. Carbohydrates provide energy, while protein is critical for animal growth, body maintenance, and output of products like milk, eggs, and wool (Chadd et al., 2004).

The energy component is measured in “metabolizable energy” (ME), which is gross energy after subtracting the energy lost in feces and urine. Uncooked rough rice contains an estimated 1,335 kcal/lb in ME for poultry feed rations or 1,075 kcal/lb in ME for swine feed rations (Appendix table A). Note that while the data available are in terms of rough rice, either rough or milled rice may be fed to livestock. Rough rice has poorer digestibility and palatability due to the hull layer, which is removed during milling (Gadberry et al., 2007). The incidence of milled or rough feeding will depend on milling capability and storage.

Rough rice is lower in ME than yellow corn, sorghum, and hard wheat for poultry feeds. For swine feeds, all grains and oilseeds listed in Appendix table A are estimated to have higher ME than rough rice with the exception of rice bran and wheat bran.

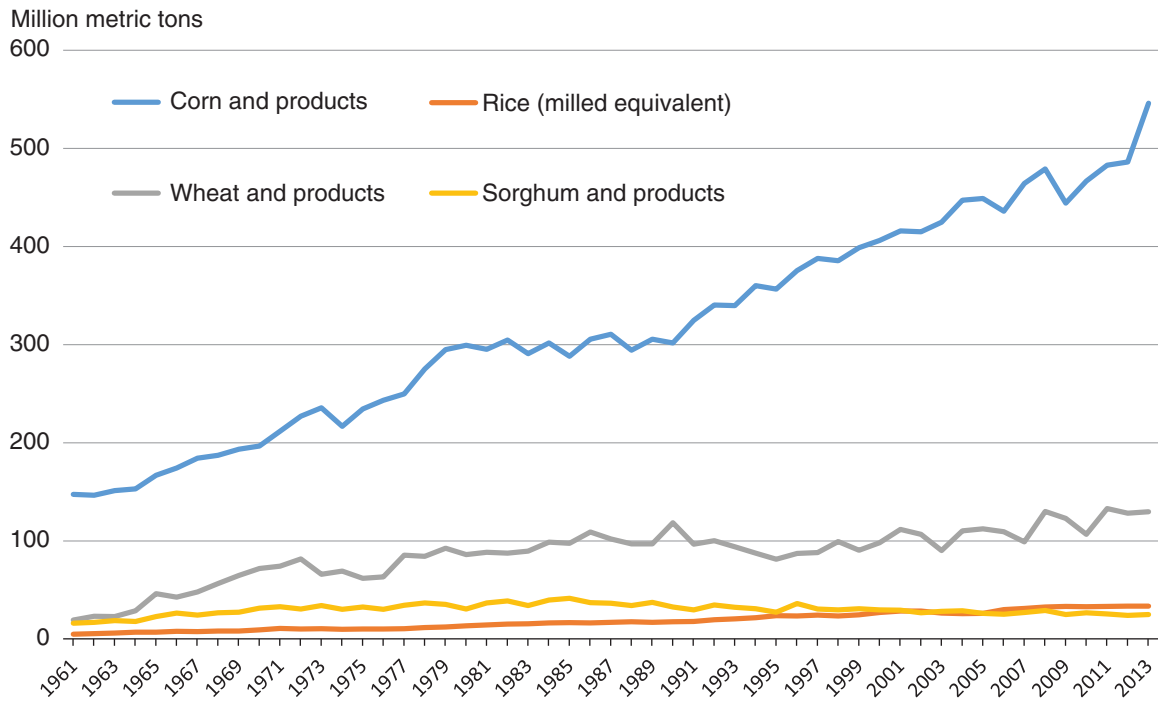
Rice has a low concentration of protein, but a relatively high concentration of lysine in its protein. The majority of cereals are limited in (or lack) certain amino acids. A missing amino acid in an ingredient, called a “limiting amino acid,” will impede protein synthesis. Lysine typically is the first limiting amino acid (DeRouche et al., 2007). Lysine constitutes about 3.3 percent of the protein in rice, compared to 2.5 percent in sorghum and 3 percent in wheat. The total lysine content in rice is low (0.24 percent), which is typical of cereal grains. Given its low protein content, rice is most likely to substitute for other cereal grains used for providing energy, such as corn, sorghum, barley, wheat, and oats, while protein requirements would be achieved through the addition of soybean meal or animal byproducts.

Unlike whole rough rice, rice bran, a byproduct of milling rice, is sometimes used in U.S. livestock feed.³ Rice bran is also one of the largest locally produced energy sources for feed in Vietnam.⁴ Rice bran is a good source of Vitamin B and is palatable to animals (Gohl, 1981), as well as having a higher lysine content than rough rice. However, its high oil content makes it vulnerable to rancidity if stored for long periods.

³Other uses of rice bran in the United States include as a deer attractant (to bait deer during deer hunting season) and in dog food formulas.

⁴Vietnam is estimated to source 18.6 percent of feed ingredients from rice in 2018 (Tran, 2017).

Figure 2
Global volume of corn, rice, wheat, and sorghum for feed use, 1961-2013



Source: United Nations, Food and Agriculture Organization.

Rice-Related Government Policies in South Korea, Japan, Thailand, and China

Rice has been of immense importance in Asian countries, dominating consumption and employing a large portion of the farm labor force. As these countries developed, they instituted policies promoting rice self-sufficiency, setting price floors or ceilings, controlling domestic rice sales, protecting domestic prices from international market fluctuations, and providing rice rations (Barker et al., 1985).

A 2015 report by the U.S. International Trade Commission found higher levels of government intervention affecting trade and price trends in the global market for rice than for other agricultural products. In many major rice-consuming countries in Asia, it found rice-centric policies that support increased rice production, limit imports, and provide incentives for growers to continue planting rice (USITC, 2015). These policies inflate prices or the effective price producers receive. They also attempt to provide growers with stability via border policies, government storage schemes, or less commonly, subsidized crop insurance policies.

The effects of stock-building policies can be important for global markets because over 90 percent of the world's rice stocks are in Asia, and much of it is under government control (USITC, 2015). Governments may hold stocks as assurance against emergencies (such as food shortages and crop failures) or tight global supplies that could lead to global price spikes, or to increase prices received by farmers. In general, government purchases insulate rice prices and provide price and demand stability regardless of fluctuations in market demand (Dawe and Timmer, 2012).

In South Korea, the Government has historically subsidized rice planting. From 1948 to 2005, it increased domestic farm prices by purchasing large amounts of domestic rice and paying farmers more than it charged consumers when it resold the rice. From 1990 to 1994, for example, farmers received about 180 percent of their cost of production from Government purchases (Choi et al., 2016). However, the Government agreed to reduce spending on rice farmers after the 1995 World Trade Organization (WTO) Uruguay Round Agreement on Agriculture classified subsidies that are coupled with particular commodities as falling within the WTO's "amber box" (i.e., an agricultural policy that distorts production and trade). To replace the high prices paid for rice, the Government introduced several direct payment programs to support farm household income. In 1999, the Government began the Direct Payment for Environment-Friendly Farming program, compensating farmers for using environmentally friendly farming methods. In 2005, it introduced the Direct Payment Program for Rice Income Compensation based on each farm's historical rice area, thus decoupling it from current rice production. The program also includes a deficiency payment (classified within the WTO amber box). Currently, the payment is 85 percent of the difference between the national average market price and a target price set by the Government for that year, minus the area payment (Choi and Hinkle, 2018). The policy does not take into account the quality of output in its calculations, which encourages higher yields.⁵ Production of rice in South Korea increased annually from 2013/14 to 2015/16, though it declined in 2016/17 and 2017/18.

⁵For an in-depth review of South Korea's rice market policies, see Choi et al., 2016.

Similarly, Japan's policies were historically designed to protect the domestic rice industry. Currently, the Government controls rice exports and imports, but until the early 1990s, it also purchased all domestic rice production. Since the Government relinquished the sole right to purchase domestic rice, it has purchased a set annual amount of 200,000 metric tons (mt) of new-crop rice, which has allowed rice prices in Japan to fall. Since 1971, Japan also has had a production adjustment program to remedy overproduction of table rice and restrict supply. The program ensures that paddy fields are maintained (and can grow rice, if necessary) by diverting them to production of other crops. Current policies incentivize production of feed-quality rice and other crops on the maintained rice paddy fields (Fujibayashi, 2018a). The subsidies provide farmers an income equal to or greater than that from table rice production and allow the domestic rice price to rise above the equilibrium price given no intervention (Martini and Kimura, 2009).

In Thailand, the Government had several rice purchasing programs from 1981 to mid-2014 to reduce the volatility in farmers' received prices. Under Thailand's Paddy Pledging Program (2011-14), farmers pledged to sell their rice to the Government, which purchased it at harvest time at prices 40 to 50 percent above the world market price for white rice and 30 percent above the world market price for fragrant rice. Thailand's Finance Ministry estimated that the Government spent over \$22 billion to support prices during the life of the program (Welcher, 2017). In 2014, a new Government ceased the paddy pledging scheme and subsequently allowed pledging only for glutinous and fragrant varieties to stabilize falling prices. In June 2015, the program was extended for these varieties to include low-interest loans and direct payments for drought-affected areas. In late 2016, declining farm gate prices led the Government to extend the rice pledging program to all rice types to help stabilize and maintain prices. Currently, Thailand's rice purchase program is limited to a specified amount of rice, with the intervention price reportedly lower than the market price (Welcher, 2017). Supplemental subsidies to farmers in Thailand include direct payments for harvest and post-harvest handling costs, as well as assistance for storage costs. Including the additional subsidies in farmers' payments yields an intervention price 20 to 40 percent above market price (Prasertsri, 2016a).

Rice-related policies in China, the world's largest rice consumer and producer, are influenced by food safety, as well as its desire for self-sufficiency. The "No. 1 Central Document," the first document published by the Government each year, has focused on agriculture for 15 consecutive years. In line with the increased focus on agriculture and self-sufficiency, the Government raised rice support prices annually from 2008 to 2015, which resulted in overproduction. In 2016 and 2017, it lowered the minimum purchase price slightly. Despite these reductions, prices remain well above international prices, making Chinese rice generally uncompetitive in the global market and encouraging greater imports from lower priced Asian suppliers.

Japan, South Korea, and China also have policies governing rice imports. Japan and South Korea maintain a stable level of imports, adhering to WTO commitments for minimum market access.⁶ Japan's imports are fixed at 7.2 percent of base-period consumption, with a prohibitive tariff level of 341 yen/kg outside that quota (Fukuda et al., 2003). In 2014, South Korea's progressive minimum-access import commitment on milled rice increased to 408,700 mt, and it remains at that level.⁷ Although the Government agreed to a commitment on a milled basis, South Korea regularly imports less-processed brown rice.⁸ China increased rice imports after it joined the WTO in December 2001. Since market year (MY) 2013/2014, its rice imports have been between 4.4 million and 5.9 million mt.

⁶During the WTO Uruguay Round negotiations (1986-1994), Japan and South Korea opted for "tariffication" (i.e., converting all non-tariff trade barriers into tariffs). The minimum market access instrument uses a tariff-rate quota, combining quotas (a maximum amount of a good that may be imported) and a tariff (a charge on the good imported). The tariff-rate quota includes a duty for the goods imported under the quota, and a duty for any amount that exceeds the quota. Prior to the Uruguay Round, Japan had retained rights to have an effective ban on rice imports, only importing if a failure in domestic crop production occurred (Dyck et al., 1999).

⁷The Government of South Korea can award a minimum-access tender to any country assigned as a most-favored nation with an in-quota tariff of 5 percent. Over-quota amounts are subject to a tariff of 513 percent.

⁸Brown rice is rice with the hull removed but bran layer remaining, typically 80 percent of the weight of paddy rice (the whole rice grain with the hulls).

Decreases in Consumption of Table Rice

Table (or food) rice consumption is heavily affected by tastes, incomes, and the price of substitute goods. As countries industrialize and urbanize, they undergo a “nutrition transition,” increasing the share of animal-sourced foods, vegetable oils, fruits, and vegetables in place of cereals, roots, and tubers (Regmi et al., 2001; FAO, 2017).

In 2016, South Korea’s estimated total annual table rice consumption per capita was 61.9 kg, a decline of 1.6 percent from 2015 and 14.8 percent from 2011. This continued a downward trend in rice consumption lasting more than five decades (KOSIS, 2017).

Similarly, Japan’s yearly per capita rice consumption was estimated at 54.6 kg in 2015, a decline of almost 2 percent compared to the prior year and 6 percent compared to 2011 (Fujibayashi, 2017). Household (2 persons or more) rice purchases have decreased every year from 2009 to 2015 (MAFF, 2018a).

In Thailand, the average annual per capita consumption of table rice was reported at 106 kg in 2016, higher than South Korea and Japan, but trending down (Prasertsri, 2016b).

The United Nations Food and Agriculture Organization (FAO) estimates that annual per capita rice consumption in China was 77 kg in 2013, equivalent to the previous year’s consumption and up 1 percent compared to 2009. While total average rice consumption has increased, it has decreased in higher income households, which instead consume lower quantities of higher quality and more expensive japonica rice (Gale and Huang, 2007).⁹ Consumption patterns in China are expected to continue to change as the number of middle- and high-income households increases. In addition to rising incomes, decreases in rice consumption in China have also been attributed to increased demand for meat, dairy, and vegetables, and the emergence of e-commerce food-delivery platforms (Kim, 2018b).

⁹China grows japonica (short- and medium-grain rice) and indica (long-grain rice). Japonica varieties are grown in northeastern provinces and fetch a premium over indica varieties. In 2016, milled japonica rice had an 11-percent price premium over indica rice (CNBS, 2017).

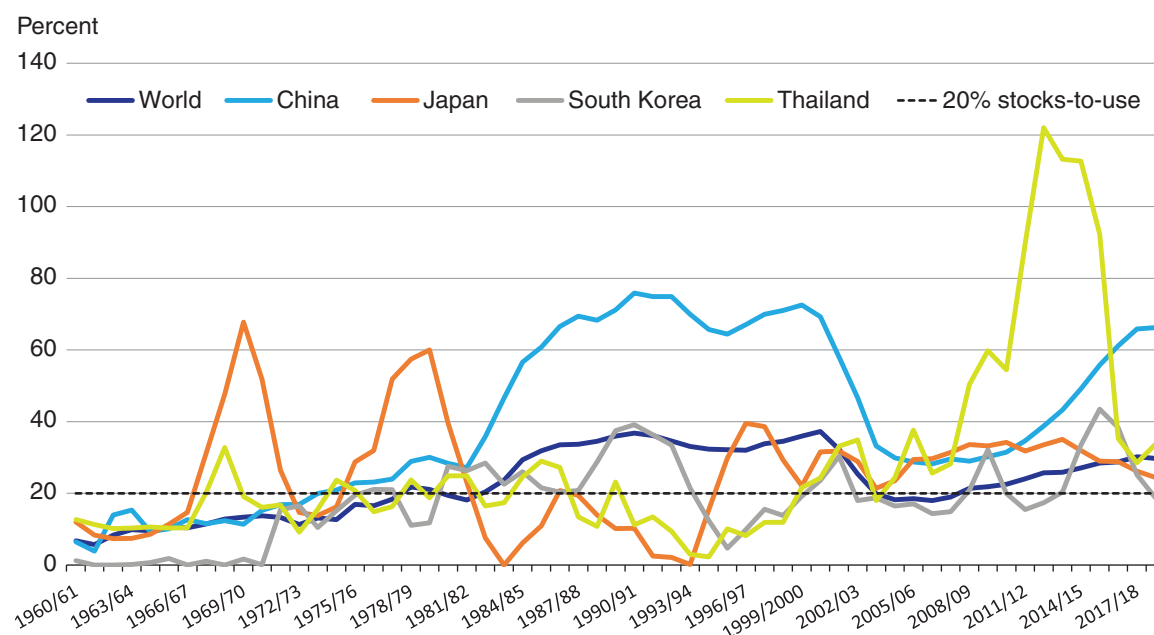
Rice Policies and Lower Consumption Result in High Stocks

Total world rice consumption is expected to increase slightly in MY 2017/18, according to USDA's World Agricultural Supply and Demand Estimates (WASDE) (USDA, 2018). Production is expected to grow faster than global use, resulting in rising global stocks. Actual stocks in Asia are more likely to be higher than those reported by USDA's Foreign Agricultural Service (FAS), which is one of the few agencies reporting global stock estimates. Especially in the case of China, where Government stocks are considered a state secret, levels of stored rice are hard to gauge. Global ending stocks, the difference between a year's total supply and total use, have increased every year since MY 2006/07, according to the USDA-FAS Production, Supply and Distribution (PSD) database.

The combination of country-specific policies and consumption patterns led the stocks-to-use ratio (the ratio of carryover stocks to total use) to grow substantially in the four countries on which this study focuses (fig. 3). The stocks-to-use ratio in China, Japan, South Korea, and Thailand was recently above 20 percent, the ratio recommended by FAO, a level that could supply about 75 days of use.

South Korea's ending stocks significantly increased from 2013/14 to 2015/16. In 2015, the Government began selling rice from stocks for feed, and in 2016/17 and 2017/18, rice production decreased by 3 percent and 7.6 percent, respectively. In 2016/17, the Government was successful in reducing stocks. USDA projects ending stocks will decline again in 2017/18 to 1.23 million mt, which is still considered high, and further decrease to 0.84 million mt in 2018/19, below the 20-percent FAO target level (Choi and Hinkle, 2017a).

Figure 3
Trends in global, China, Japan, South Korea, and Thailand stocks-to-use ratios, 1960/61-2018/19



Source: USDA, Foreign Agricultural Service, Production, Supply and Demand database.

The Government of Japan holds 910,000 mt (brown equivalent) of domestically produced rice as regular contingency reserves and, as reported earlier, purchases approximately 200,000 mt of the domestic new crop every year. It also holds in storage imported rice purchased under Ordinary Market Access (OMA), its program for minimum market access. The decrease in table rice consumption led to stocks exceeding 2.8 million mt from 2008 to 2014. In 2015, the Ministry of Agriculture, Forestry, and Fisheries (MAFF) encouraged farmers to reduce production of table rice to reduce excessive stocks.

During Thailand's Paddy Pledging Program, ending stocks reached 9.3 million mt in MY 2011/12, 40 percent higher than in MY 2010/11, and swelled to 12.8 million mt, an additional 27 percent, in 2012/2013. In September 2014, an audit by Thailand's Ministry of Finance estimated the Government had 17.5 million mt in rice stocks accumulated through the Paddy Pledging Program, which was discontinued after MY 2013/14. It found that about 43 percent of the stockpiled rice was unfit for domestic and export human consumption, encumbering the Government's rice marketing. In 2017, the Government began auctioning off Government rice to decrease its stocks.

USDA estimates that China holds almost 70 percent of the world's rice stocks. USDA forecasts China's ending stocks of rice for 2018/19 will surpass 95 million mt.

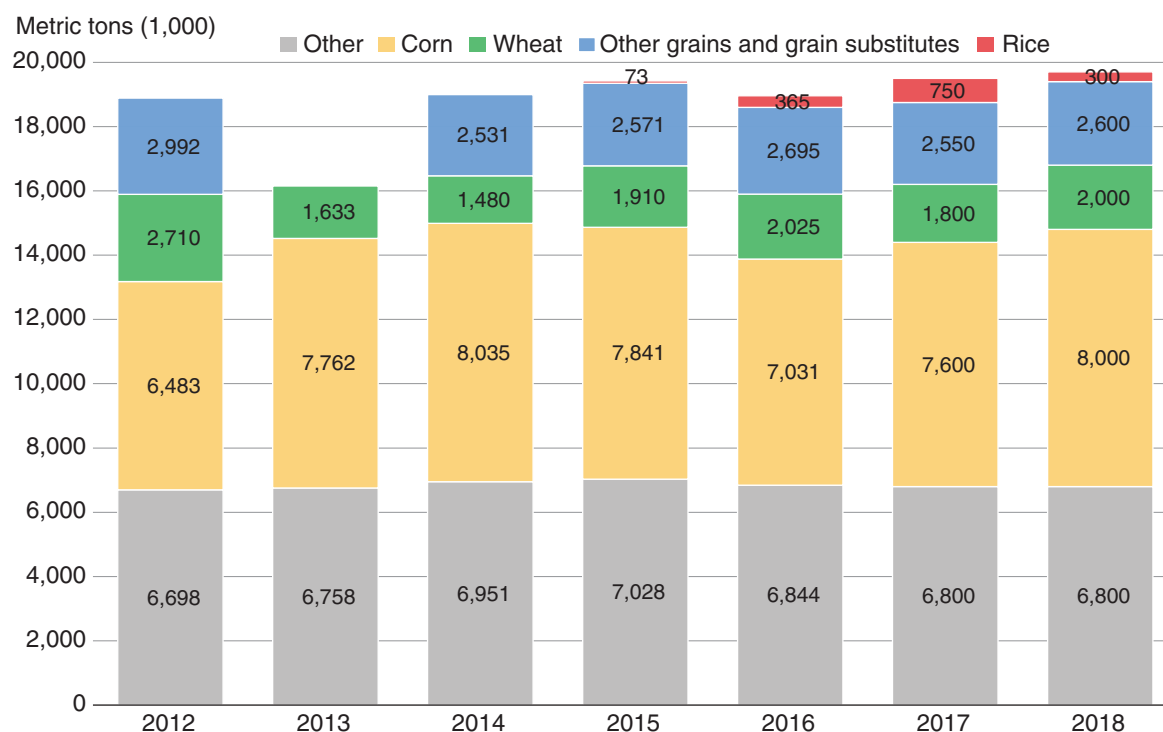
While the stocks-to-use ratio in China continues to rise, South Korea, Japan, and Thailand have been successful in reducing their stocks-to-use ratios, and all have sold rice from stocks to feed markets.

Use of Rice as a Feed Grain

Global use of rice for livestock feed has steadily increased over the past several decades despite the lack of historical use of rice for feed. FAO reports global use of rice for feed in 2013 at 33.6 million mt, or 6.7 percent of total rice use. Feed use has been growing by 0.5 million mt per year since 2003, an average growth rate of 1.7 percent (FAO, 2018).¹⁰

Prior to 2015, rice was not sanctioned for feed use in South Korea (fig. 4). The subsequent release of rice from stocks for feed, while low, has allowed the South Korea Government to sell old-rice stocks and reach its target stock level. In MY 2017/18, feed rice sales included rice produced domestically and rice imported from China under South Korea's 2014 minimum market access agreement. The amount of rice earmarked for feed consumption will decrease in MY 2018/2019, with Korea's old-rice stocks expected to be depleted by the end of the 2018 calendar year (Choi and Hinkle, 2018).

Figure 4
Ingredients used for compound feed production in South Korea, 2012-18



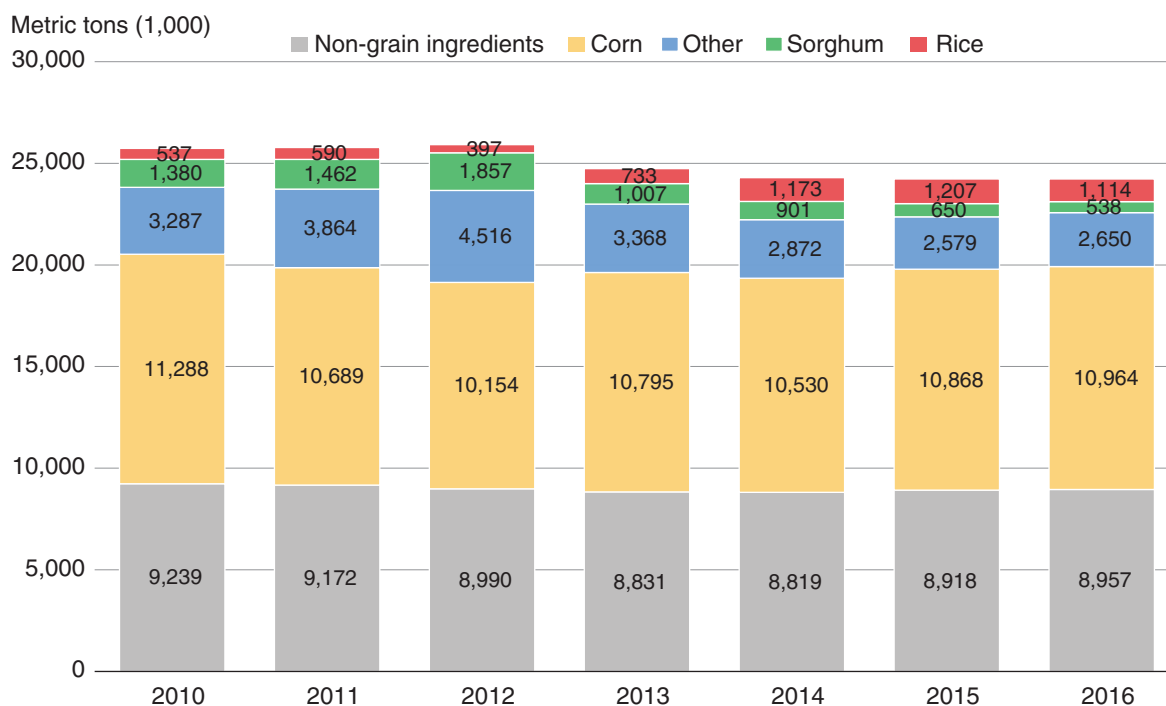
Source: Korea Feed Association and USDA, Foreign Agricultural Service (FAS) Seoul (market year (MY) 2016/17 and MY 2017/18). 2016-2018 represent FAS Seoul forecasts as of April 2018.

¹⁰FAO Food Balance Sheets are the only source of global data for alternative rice uses, distinguishing between consumption and use in food, feed, processing, seed, losses, and other categories. The data combine available information on “seed rates, waste coefficients, stock changes and types of utilization (feed, food, processing and other utilization)” to create supply/use accounts (FAO, 2017). The latest estimates are for calendar year 2013. USDA’s Production, Supply and Distribution database publishes more recent use estimates but aggregates food, feed, industrial, and seed use at the country level.

In Japan, rice for feed use still constitutes a small portion of total rice use, though the use of rice in feed increased by 180 percent from 2012 to 2016 (fig. 5). Rice measurably cut the use of other ingredients during MY 2014/15 (Fujibayashi, 2016). Rice supplied to the livestock industry can come from Government stocks or be grown specifically for feed consumption. Japanese production of rice grown specifically for feed increased by 204 percent from 2012 to 2016.¹¹

While Japan distributes both domestic and imported Government-owned stocks for feed, the majority of rice sold to feed markets from Government stocks from 2006 to 2013 was imported rice (fig. 6).¹² According to the Ministry of Agriculture, Forestry, and Fisheries (MAFF), 96.2 percent of rice purchased under its Ordinary Market Access (OMA) program was sold for feed use during MY 2016/17, and an average of 69.8 percent was sold for feed use over marketing years 2005/06 to 2016/17. Although the majority of the Government’s stocked rice is used for livestock feed, a small amount of table rice has been re-exported as food aid or released for table or industrial use.¹³ USDA-FAS expects the use of rice in feed markets to decline due to currently competitively priced alternatives and decreased OMA rice supplies (Fujibayashi, 2018b).

Figure 5
Ingredients used for compound feed production in Japan, 2010-17



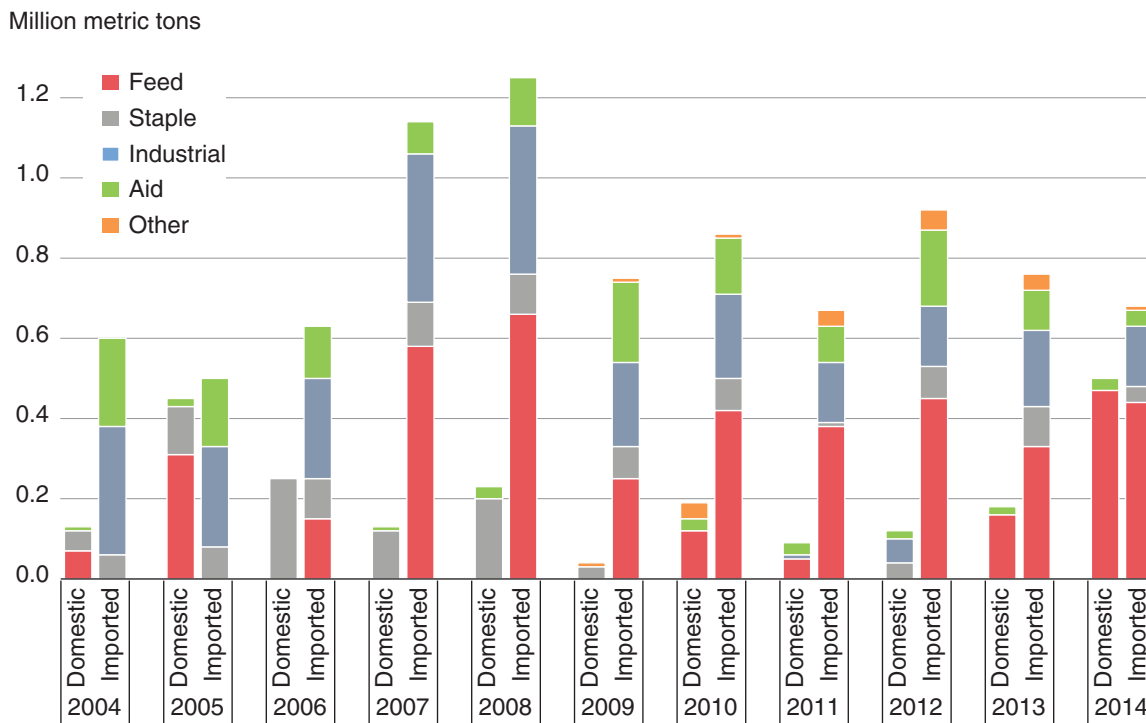
Source: Japan Ministry of Agriculture, Forestry, and Fisheries.

¹¹Despite Government subsidies, planted area of feed rice increased only marginally in MY 2017/18 due to high table rice prices.

¹²Japan purchases imported rice via Simultaneous-Buy-Sell (SBS) and Ordinary Minimum Access (OMA) tenders. SBS is imported for table rice consumption, and OMA for Government stocks. In addition, the Government of Japan holds 910,000 mt (brown equivalent) of domestically produced rice as regular contingency stocks, selling 5-year-old rice from reserves to feed and processing (Fujibayashi, 2018a).

¹³WTO regulations disallow member nations from re-exporting rice, with the exception of small quantities in food aid.

Figure 6
Sales of Government-owned rice in Japan, 2004-14

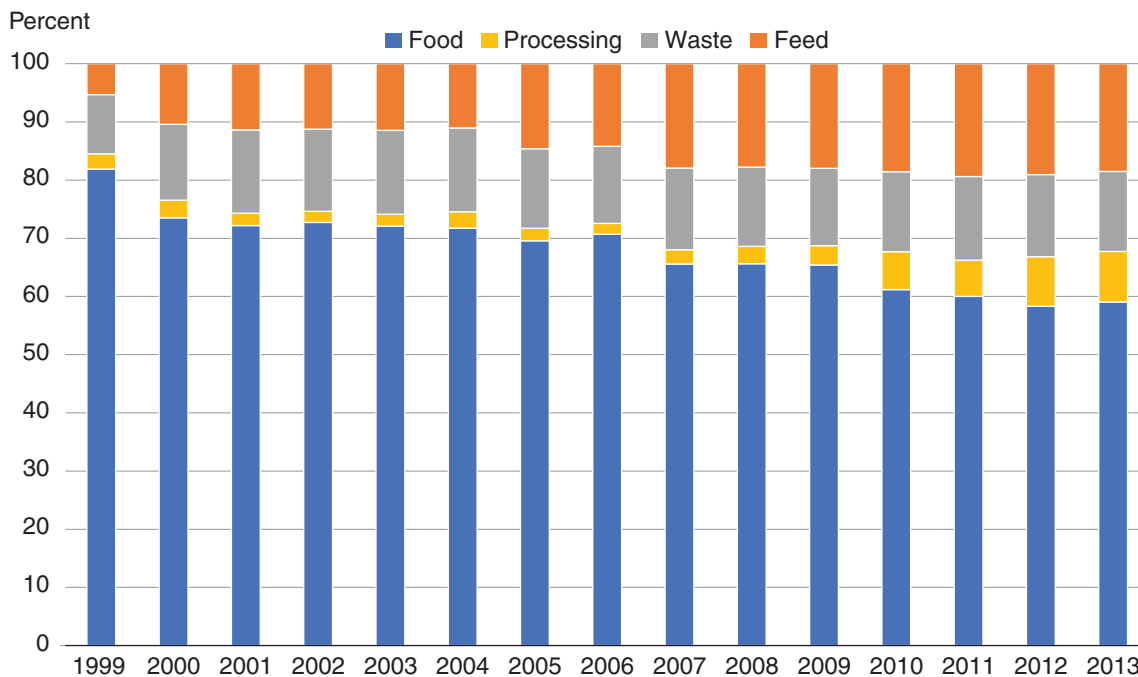


Source: Japan Ministry of Agriculture, Forestry, and Fisheries.

In contrast to the limited prior use of rice for feed in East Asian countries such as Japan and South Korea, FAO estimates that the practice has been steadily growing in Thailand (fig. 7). Rice use in feed increased after the end of the Paddy Pledging Program. Recall that when officials graded the accumulated Paddy Pledging Program stocks, they found a large portion to be substandard and deemed it fit only for feed consumption or industrial use due to poor handling and storage conditions. In mid-2016, the Government concluded that out of the 8.4 million mt of old-crop rice it held, half was not food-grade quality. In 2017, the Government began auctioning its old-crop rice stocks and concluded that process in June 2018 (fig. 8) (Prasertsri, 2018).

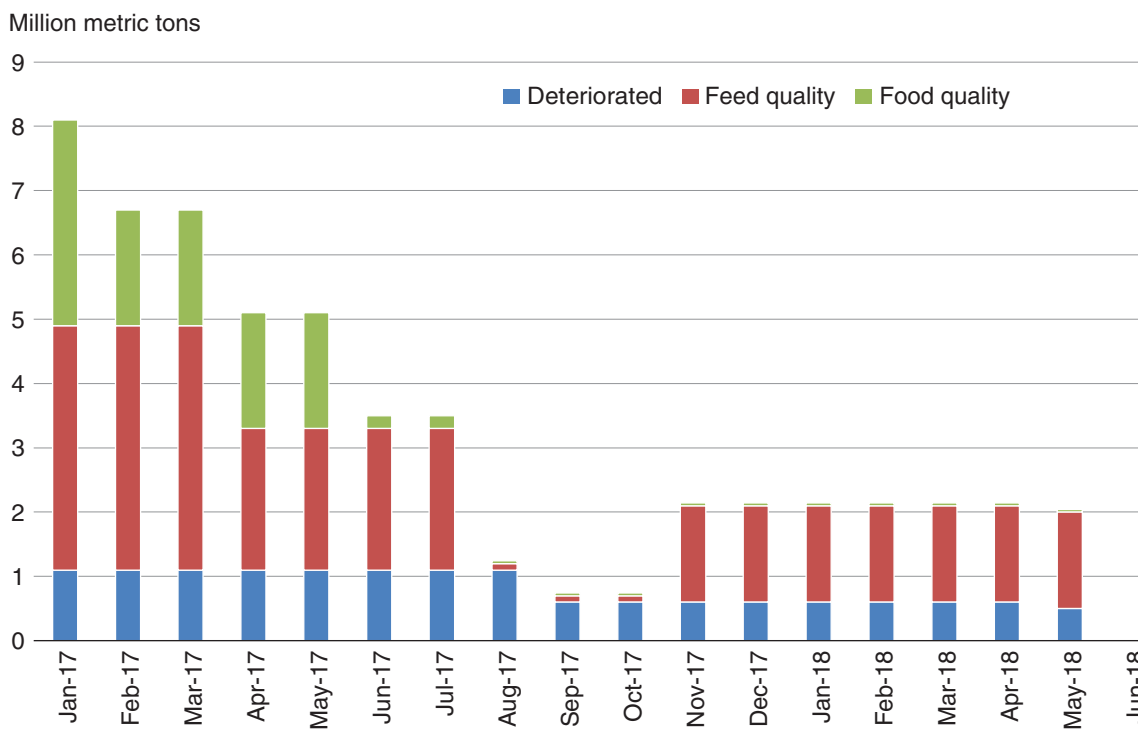
The distribution of rice in China is more difficult to determine. FAO estimates that rice consumption has been relatively stable, with about 10 percent dedicated to feed use, although the volume is estimated to have increased from 2.9 million mt in 1961 to 12 million mt by 2013. These estimates are relatively close to those released by Chinese agencies: the China Ministry of Agriculture estimates that about 8.5 percent of rice is used in feed, but it projects feed use will increase to only 8.6 percent by 2027 (MOA, 2018), and the China National Grain and Oils Information Center says the feed industry uses 7 percent of rice (CNGOIC, 2018). Despite the consistently low use of feed rice in the past, decreasing rice prices and surging corn prices could lead feed producers to consider rice as an alternative energy source for feed in the future (Kim, 2018b).

Figure 7
Distribution of rice use in Thailand, 1999-2013



Source: United Nations, Food and Agriculture Organization.

Figure 8
Thailand Government old-crop rice stocks



Source: Thailand Ministry of Commerce and USDA, Foreign Agricultural Service.

Effect of Releasing Rice Stocks Into Feed Markets

Typically, high-quality or table-grade rice is not competitively priced as a feed grain. Rice prices tend to be higher than those for feed grains such as corn and wheat. Therefore, the cross-price elasticity of demand for high-quality rice with other feed crops is likely near zero. In other words, a small decrease in the price of high-quality rice does not affect the quantity demanded of typical feed crops. However, when rice is diverted from food and sold for feed at low prices, it shifts the supply curve of feed grains to the right (or up), decreasing the equilibrium price of feed grains. And as feed rice is a substitute for other feed grains, it shifts the demand curve for alternative grains to the left (or down).

The outlook and feasibility of rice as a feed crop is contingent on its price relative to other grains, especially corn. Given the price of rice and its nutritional content compared to other carbohydrates available for feed, rice is unlikely to be competitive without subsidization (see box, “Nutrition and Viability of Rice as a Feed Grain”).¹⁴

As is the case with all cereals, rice is a differentiated product with regard to quality (i.e., ordinarily, only lower quality rice will be used for feed). Therefore, the use of rice as a feed grain may have a small impact on the rice market. However, the release of old stocks for alternative uses can increase table rice prices because it decreases supply. Feed rice could also affect the demand for crops more traditionally used for feed. The possible effect on imports and exports of feed grains is of interest to the United States because it is a major exporter of feed crops such as corn and sorghum. Lower priced feed-grade or surplus rice could shift demand away from grains typically used as feed. While South Korea, Japan, and Thailand have observed an effect on alternative grain markets when rice is allowed into feed markets, they differ on the types of feed domestically produced and imported.

Corn is the most-used ingredient in South Korea’s compound feed production (fig. 4).¹⁵ Corn and wheat, which combined make up about 50 percent of its compound feed production, are typically imported. South Korea imports feed-quality wheat from Ukraine, Russia, France, Bulgaria, and Brazil. It imports corn from the United States, Russia, Brazil, Ukraine, and Argentina. South Korea is the sixth largest market for U.S. agricultural exports. Under the U.S.-Korea Trade Agreement (KORUS), wheat, corn, soybeans for crushing, and whey for feed use are imported to South Korea duty free (USDA-FAS, 2011). When the Government releases feed rice from stocks, it prices it for sale below the previous marketing year’s corn values (Choi and Hinkle, 2018) and at a 10th of the purchase price in its harvest-season purchasing program (Choi and Hinkle, 2017a). The feed rice price policy can have the greatest impact on wheat, given its relatively high price compared to feed rice and corn (Raszap Skorbiensky and Dyck, 2017). But the increase in availability of competitively priced feed rice coupled with other market forces, including an outbreak of Highly Pathogenic Avian Influenza (HPAI) in late 2016 and 2017 that reduced the need for corn for poultry feed, also decreased corn used in feed (Choi and Hinkle, 2017b).

¹⁴On the other hand, rice byproducts are used for feed without government intervention. Broken kernels (called “brokens”) of locally grown rice, as well as other rice byproducts, are sometimes used as a substitute for feed corn, wheat, and cassava in rations for swine and poultry in Southeast Asia. The byproducts of locally grown rice have a transportation advantage over other feed grains; feed consumers typically import corn and wheat, which adds to their total cost. Thus, depending on relative prices, byproducts can be financially viable for farmers (Baldwin et al., 2012).

¹⁵Compound feed is a blend formulated to provide specific nutritional requirements to an animal. The blend will typically include several raw materials and additives.

Corn constitutes about 50 percent of Japan's compound feed production (fig. 5). Despite the importance of corn as a feed grain, Japan does not produce a significant amount domestically. In 2016/17, Japan imported 15.2 million mt of corn, 13.5 million mt of it from the United States. Japan accounted for 22 percent of U.S. corn exports during the 2015/16 crop year, second only to Mexico. Japan imports U.S. wheat under a zero-tariff agreement with an out-of-quota duty of 55 yen/kg. It has no tariffs on imports of U.S. corn for feed.¹⁶ Mills in Japan can substitute almost 12 percent of brown rice for corn in compound feed recipes, given similar prices. The mills will purchase feed rice from Government stocks if its price is comparable to the feed corn price.¹⁷ During MY 2014/15, rice measurably cut the use of other ingredients (Fujibayashi, 2016). Revenue from feed rice is less than 10 percent of that for table rice, so the Government subsidizes over 90 percent of feed rice income (Fujibayashi, 2017).

Thailand's feed industry relies on imports for 50 to 60 percent of total feed (Prasertsri, 2017a). Thailand produces corn domestically, but imports almost all of its supply of feed wheat, soybeans, and soybean meal. In the past 3 years, Thailand imported an average of 29 percent of its soybeans, 20 percent of its soybean residues, and 2 percent of its corn from the United States. During the first half of 2017, Government sales of deteriorated rice substituted for corn and feed wheat in swine and duck feed rations (Prasertsri, 2017b). The Government auctioned the old-crop, feed-quality rice at prices 30 percent below the price of corn and 30 to 35 percent below the price of imported feed wheat (Prasertsri, 2017c). In early 2017, the Government provided additional incentives for the use of rice in feed rations by restricting feed wheat imports (Prasertsri, 2017a). Now that Thailand has completed its auction of old-crop feed rice, the use of rice in feed is expected to decrease.

¹⁶The amount of feed wheat to total U.S. wheat exports to Japan is relatively small, 12, 9, and 6 percent for 2013, 2014, and 2015, respectively. However, from 2013 to 2015, over 40 percent of Japan's feed wheat imports originated from the United States. In 2016, the share of imported U.S. feed wheat fell to 4 percent. Initially, high corn prices in 2012 had led to an increase in feed wheat use. In 2017, the price of U.S. feed wheat was \$216.20 per metric ton CIF (Cost, Insurance, and Freight), compared to the world price of \$202.40. More recently, Black Sea countries have had feed wheat prices that can compete with current feed corn and feed sorghum prices.

¹⁷MAFF sells rice through tenders, and prices for both corn and feed rice fluctuate. Domestically produced feed rice traded at 30,000 yen/mt, 5,300 yen over current feed corn value (about \$50/mt) (MAFF, 2018b).

Baseline Analysis: Effect of Releasing Feed Rice in China's Feed Markets

As the world's largest producer and consumer of rice, China is an important player in the global rice market. At the same time, China is the largest consumer of feed grain. It produces the majority of its feed corn, the chief carbohydrate source for its livestock feed. In addition, China ranks among the top five importing countries for feed grains.

As consumption of rice has increased at a slow pace, the Government has built up large rice stocks (as well as corn and wheat stocks). Chinese policymakers have prioritized the disposal of excess stocks of several commodities, including rice. Current discussions are centered on the disposal of rice into ethanol markets, but consideration is also being given to rice as an alternative to corn as an energy source in livestock feed if rice prices continue to move down (Kim, 2018b). China would be the newest, and by far the biggest, example of the established practice of diverting rice stocks to livestock feed among emerging markets in East Asia.

We employ the USDA baseline model to measure the possible effect of a policy change that would increase feed use of rice starting in 2018/19 (see box, "The USDA-ERS Baseline Model"). The partial equilibrium model comprises 44 country and regional models that are solved together for global trade equilibrium and world prices (USDA, 2018). It uses commodity supply and demand data from the USDA-FAS Production, Supply and Distribution (PSD) database and FAO's FAOSTAT, as well as theoretically consistent elasticities derived from research and expertise.

The USDA-ERS Baseline Model

The USDA-Economic Research Service (ERS) baseline model is a multi-country, multi-commodity dynamic partial equilibrium simulation model. It is made up of 44 country or regional models. Its China model includes 28 commodities; among them are rice, corn, sorghum, wheat, barley, and soybeans. Yearly planting decisions are based on relative expected net or gross revenue, depending on data availability. Using these data as well as assumptions regarding policy and trends, the model balances supply and demand of the included commodities. It uses elasticities that are believed to be theoretically consistent and reasonable (when compared to similar commodities), and generates results that country and commodity experts believe to be consistent.

The model is useful for policy analysis because it allows analysis of changes to projections brought on by exogenous shifts in the market. In this report, the model is used to examine the impact of a shift of rice in certain countries' feed market on domestic and global feed markets. The baseline model has the advantage of also connecting indirect markets, allowing feedback changes to occur domestically and globally. A shift in the demand curve for feed rice shifts curves for related commodities and countries, allowing us to obtain a theoretical understanding of the impact, given the assumed elasticities and fitted demand and supply equations for each commodity.

In accordance with regulations of the Government of China, domestic prices for corn, wheat, and rice are protected from international market shocks. Feed grain demand depends on the type of livestock operation, production, and feed prices. The USDA-ERS model links the China model to other available country/regional models, including one for the United States. It solves for global trade and world prices and domestic production, consumption, ending stocks, trade, and prices for all commodities and countries.

The linked model assumes that current international laws, policies, and trade agreements continue into the future. It also assumes that population growth rates slow in most developing countries, though remain high in Africa, and that the trend to greater urbanization continues.

Simulation Details

In our simulated scenario, China releases rice from stocks for feed use under two assumptions. Under either assumption, China slowly increases the amount of rice used for feed each year, reaching an annual release of 10 million mt in 2026/27. Under either assumption, the accumulated amount of rice released by the end of the simulation period equals 40 million mt.

Baseline: The baseline for consumption, production, prices, and trade is the *USDA Agricultural Projections to 2026* (USDA, 2017).

Scenario with assumption 1: “Stock assumption.”

- China releases a total of 40 million mt of rice stocks for use as livestock feed over 10 years, with 10 million mt released in 2026/27
- Substitution of rice for corn in China feed markets, increasing China corn stocks

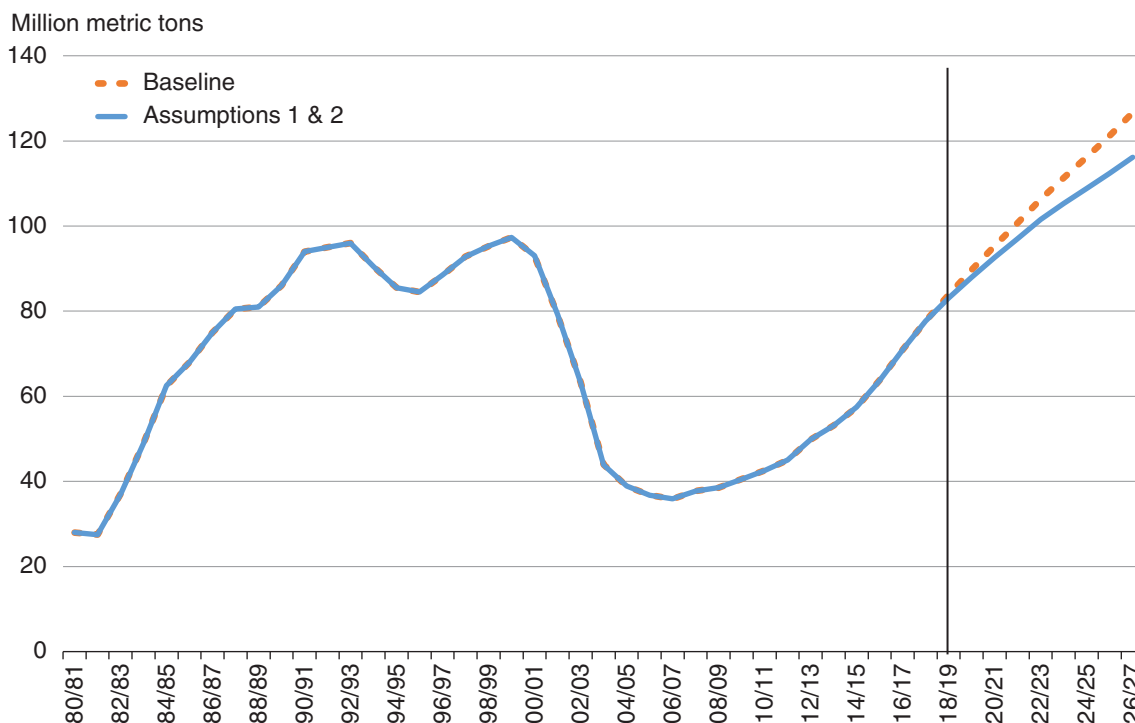
Scenario with assumption 2: “Import assumption.”

- China releases a total of 40 million mt of rice stocks for use as livestock feed over 10 years, with 10 million mt released in 2026/27
- Substitution of rice for corn in China feed markets, offsetting China corn imports

Results compare output from assumptions 1 and 2 to the baseline rice stock level forecast (fig. 9).

Figure 9

China baseline and scenario rice stock levels, market years 1980/81-2026/27



Source: USDA, Foreign Agricultural Service, Production, Supply and Demand database and USDA, Economic Research Service baseline and simulation results.

While the assumptions differ in how they substitute the newly introduced rice into the feed markets, both cause shocks to the corn market (table 1).

We choose to substitute feed rice for feed corn for several reasons. First, feed corn is the most commonly used energy feed source in China. Furthermore, the price of rice has continued to decline while the price of feed corn has been trending upward, increasing the potential of using rice as a livestock feed source (Kim, 2018b). Also, while our model is not spatial in nature, the north-east region of China has expanded rice area (Kim, 2017; You et al., 2011), has had rice storage at capacity (Anderson-Sprecher and Junyang, 2014), and has less chemical pollution than southern growing regions (You et al., 2011). For these reasons, rice used in livestock feed could be sourced from the northeast region. In that case, the rice would be a closer substitute for corn feed, given that corn is predominately grown in the north.

Because rice prices are still significantly higher than corn prices in China, and feed rice is only used in limited quantities, we chose to analyze a relatively modest annual release, relative to China’s total rice stocks, of up to 10 million mt of rice stocks for feed use. While this constitutes a small percentage of China’s stocks, the absolute size is large since China is such a large rice-consuming country. For the purpose of our model, we assume an 80-percent rate of substitution of rice to corn, given the data on metabolizable energy (e.g., 10 million mt of rice will displace 8 million mt of corn).

China is also reforming its corn policy and disposing of its corn stocks. In the first scenario, we assume the released rice stocks slow the release of corn stocks, thus having the main impact on China’s domestic corn market. In the second scenario, we assume that the released rice stocks substitute for imported corn. Thus, in the second scenario, the feed market impacts are imposed on the global market by reducing China’s demand for imported feeds.¹⁸

Table 1

Assumptions and direct results

Assumption	Action	Direct result
Stocks	Substitution of rice for corn	Corn stocks increase
Imports	Substitution of rice for corn	Corn imports decrease

Source: USDA, Economic Research Service.

Effect on Rice Markets

The two assumptions have similar consequences on the domestic and global rice markets (table 2). Under both assumptions, China’s rice production increases by 4 percent when compared to the base-line. The diversion of rice into feed markets causes a decline in total rice supply, increasing its price. In both scenarios, rice imports increase by approximately 10 percent.

Meanwhile, the decrease in rice stocks has a large impact on China’s rice exports, likely of low-quality rice. Rice exports decrease by about 60 percent. A qualification is that China’s export market is still developing, such that the decrease in exported rice amounts to a decrease of only about 173,000 mt.

¹⁸To accommodate the limitations of the model, we make the simplifying assumption that China only substitutes for domestic or imported corn. However, the impacts on corn can be thought of as impacts on the broader demand for feed materials. The environment in China is also dynamic; China’s corn and wheat stocks are also large, and China has blocked imports of distillers’ dried grains with solubles (DDGS) and sorghum with antidumping and countervailing duties.

While the majority of China’s rice exports are commercial, central planners have used assistance, particularly to countries in Africa, to liquidate surplus of aged or low-quality rice (Kim, 2018b).

There is no change in China’s domestic rice price despite changes in the supply and demand balance sheet. The stability of the domestic rice price is attributable to the model maintaining the Government’s rice support prices. On the other hand, the global rice price increases by 2 percent, causing a small change in global trade flows.

Table 3 details changes in global export flows for major rice-exporting countries India, Thailand, and Vietnam and for the United States as a consequence of China implementing the scenario. Relative to the baseline, total exports increase slightly for all four nations. The increase is greatest for Thailand and Vietnam because they provide the majority of China’s rice imports. Still, the export changes are quite small. For example, under scenario 1, Thailand’s exports increase by 82,000 mt in 2026, a 1-percent change when compared to the baseline. Export changes for India are smaller despite the phytosanitary protocol signed by China and India in 2018 that allows India to export all rice varieties. The model forecasts a modest increase of U.S. exports as a result of the policy change. Compared to the baseline, total U.S. exports to all markets would be expected to increase 52,000 mt by 2026 compared to the baseline. The United States and China have signed a phytosanitary protocol, but it had not been implemented by the time this report was written.

Table 2
Changes to China’s rice market from baseline projections for 2026/27

	Assumption 1 2026/27		Assumption 2 2026/27	
	Quantity change (mmt)	Percent change	Quantity change (mmt)	Percent change
China rice stocks	-10	-8	-10	-8
China rice production	6	4	6	4
China rice imports	0.5	10	0.5	11
China rice exports	-0.2	-58	0.2	-60
Global rice global prices	4 US\$/mt (real)	2	4 US\$/mt (real)	2

Note: mt = metric ton. mmt = million metric tons. Prices indexed to 2010.

Source: USDA, Economic Research Service baseline simulation results.

Table 3
Difference in annual rice exports from baseline projections (thousand metric tons) for selected countries and years

Crop year	Exporters, assumption 1				Exporters, assumption 2			
	U.S.	India	Thailand	Vietnam	U.S.	India	Thailand	Vietnam
2018	6	3	3	5	6	3	3	5
2022	27	13	48	51	29	13	51	57
2026	52	21	82	87	56	20	90	103

Source: USDA Economic Research Service baseline simulation results

Overall, changes in global import flows are small. Import changes are driven by China’s own increased demand for imported rice and the decline in global stocks—China’s ending stocks make up almost 70 percent of global ending stocks. Table 4 details changes in import flows for two major rice-importing countries, Nigeria and the Philippines, and for the United States. The import changes are small. For example, the model estimates that Nigeria’s imports decrease by 19,000 mt in 2026, a 1-percent decrease when compared to the baseline. The scenario does not distort the rice import flow to the United States, which imports less than 1 million mt of Chinese rice, typically aromatic varieties.

Table 4
Difference in annual rice imports from baseline projections (thousand metric tons) for selected countries and years

Crop year	Importers, assumption 1			Importers, assumption 2		
	U.S.	Nigeria	Philippines	U.S.	Nigeria	Philippines
2018	0	-2	-2	0	-2	-2
2022	0	-11	-21	0	-11	-22
2026	0	-19	-36	0	-19	-39

Source: USDA, Economic Research Service baseline simulation results.

Effect on Corn Markets

As seen in South Korea, Japan, and Thailand, the introduction of rice into feed markets can temporarily displace other feed grains. Under the model simulation, both assumptions have effects on consumption and production levels in China’s domestic corn market (table 5).

Under assumption 1, our market intervention directly increases corn ending stocks by 18 percent because we assume the 10 million mt of rice is substituted for corn stocks at a rate of 80 percent. China eliminated the support price for the corn market in the fall of 2015, replacing subsidies with a direct producer payments program in 2016, allowing corn prices to fluctuate according to market forces. If rice is substituted for corn stocks, corn stocks will increase, decreasing producer prices. Therefore, assumption 1 more significantly reduces China’s corn production for feed, with an eventual decrease of 3 percent.

Relative to the baseline, the global price of corn declines by only an estimated 0.3 percent. Domestic producer prices in China feel the larger impact. Corn producer prices fall by almost 8 percent. Under this assumption, tension is on the domestic price to drop because China’s import trend stays unchanged.

Under assumption 2, rice stocks released into the market replace China’s corn imports. Because we assume that rice replaces corn at a rate of 0.8 (e.g., 1 metric ton of rice is needed to replace 0.8 mt of imported corn), corn imports fall by 85 percent in 2026/27. While China removed the price support for corn, it retains strict control of the import market. In the past, China’s import policies have prioritized self-sufficiency in cereal grains, specifically managing corn tariff-rate quotas by mostly reserving them to state traders (Gale et al., 2015). Unlike assumption 1, if the Government chooses to lessen rice stocks via reducing corn imports to offset increased rice feed demand and decreased corn feed demand, it will have a larger effect on the global corn price. The simulation predicts the global price to be 2 percent below the baseline projections for 2026/27. Price impacts in assumption 2 are passed on to global markets, while price impacts in assumption 1 are passed on to domestic producers. The domestic price received by producers falls by only 2 percent, relative to the 8 percent in assumption 1.

Table 5

Changes to China's corn market from baseline projections for 2026/27

	Assumption 1 2026/27		Assumption 2 2026/27	
	Quantity change (mmt)	Percent change	Quantity change (mmt)	Percent change
China corn production	-0.2	-3	-3	-1
China corn feed consumption	-8	-4	-8	-4
China corn ending stocks	8	18	2	4
China corn imports	-1	-14	-5	-85
China corn producer price	-179 rmb/mt (real)	-8	-41 rmb/mt (real)	-2
Global corn global prices	-0.3 US\$/mt (real)	0	-2 US\$/mt (real)	-2

Note: mt = metric ton. mmt = million metric tons. China's corn producer price in Chinese Yuan (rmb). All prices indexed to 2010.

Source: USDA Economic Research Service baseline simulation results.

Under both assumptions, lower global corn prices affect world trade patterns. In assumption 1, the small decrease in the global corn price increases demand for corn by the European Union (EU), Indonesia, Iran, Japan, Turkey, and Vietnam (table 6). However, Mexico and Thailand decrease corn imports, despite the lower price, as they substitute other grains for corn. The model simulation generates lower prices for sorghum, wheat, oilseeds, and additional feed grains. Under assumption 1, China's sorghum's imports decrease by 27 percent. The lower sorghum price provides incentives for Mexico to increase imports of sorghum. Small increases in imports of other feed grains, such as wheat, oilseeds, and soymeal, explain Thailand's decrease in corn imports.

Under assumption 2, a larger decrease in the global corn price leads to an increase in imported corn for all reported countries except China (table 7). Note that China's imports decrease because of the assumption 2 restriction to substitute rice feed for imported corn. By 2026/27, the model simulates that EU corn imports would be 502,000 mt greater than currently projected by the USDA baseline, about a 5-percent increase in corn imports.

Changes in these import flows affect major corn-exporting countries (table 8). Under both assumptions, major exporters experience a reduction in corn exports, albeit small. In USDA's baseline projections, the United States exports 50 million mt of corn in crop year 2018/19 and 55 million mt in 2026/27. Assumption 1 results in U.S. corn exports initially decreasing by 18,300 mt from a baseline amount of 50.1 million mt, a decline of essentially zero percent (0.04). By 2026/27, U.S. corn exports decline by 442,000 mt relative to the baseline projection of 55 million mt, still only a decline of less than 1 percent. If China decreases rice stocks by allowing its corn stocks to accrue and maintains a regular flow of imports, the burden of adjustment falls largely on the domestic market with little effect on the global price or import and export markets.

Table 6

Difference in annual corn imports from baseline projections (thousand metric tons) for select years and countries, assumption 1

Crop year	China	EU	Indonesia	Iran	Japan	Mexico	Thailand	Turkey	Vietnam
2018	-39	4	0	1	0	-1	0	0	3
2022	-477	39	5	7	2	-8	-3	4	22
2026	-857	69	9	12	4	-11	-5	6	40

Note: EU = European Union.

Source: USDA, Economic Research Service baseline simulation results.

Table 7

Difference in annual corn imports from baseline projections (thousand metric tons) for select years and countries, assumption 2

Crop year	China	EU	Indonesia	Iran	Japan	Mexico	Thailand	Turkey	Vietnam
2018	-468	44	3	6	4	1	4	4	8
2022	-1,740	172	15	21	9	2	8	13	39
2026	-5,169	502	44	67	26	11	31	38	95

Note: EU = European Union.

Source: USDA, Economic Research Service baseline simulation results.

Table 8

Difference in annual corn exports from baseline projections (thousand metric tons) for the world's top corn exporters

Crop year	Exporters, assumption 1			Exporters, assumption 2		
	U.S.	Argentina	Brazil	U.S.	Argentina	Brazil
2018	-18	-1	-3	-234	-19	-345
2022	-253	-21	-34	-898	-78	-131
2026	-442	-32	-91	-2,636	-229	-420

Source: USDA, Economic Research Service baseline simulation results.

Assumption 2, in which rice released into the market replaces corn (specifically that each metric ton of rice replaces 0.8 mt of imported corn), causes larger decreases in global corn exports. In 2018, U.S. global corn exports are 234,000 mt lower than baseline projections, a reduction of 1 percent. By 2026/27, assumption 2 causes U.S. corn exports to decrease by almost 3 million mt, a reduction of 5 percent. Exports also decrease for Argentina and Brazil; by 2026/27, exports by both countries would be 1 percent lower than baseline projections.

Discussion

Country-specific, rice-centric policies coupled with large rice stocks and decreasing per capita rice consumption for food have prompted governments in several Asian countries to initiate programs to shift government rice into the feed industry. South Korea, Japan, and Thailand have implemented policies in recent years to divert surplus or aged stocks to feed grain markets. In these countries, the introduction of rice as a feed grain came at the governments' expense, with the rice selling at a fraction of its initial purchase price. These policies can distort global markets, with impacts on the global price of alternative crops and global trade flows. To offset these impacts, for example, Thailand imposed controls on wheat imports and turned to using rice for feed.

China could be the next country to enact a policy that diverts rice stocks to feed use, as table rice consumption has increased slowly and policymakers search for new alternative markets for surplus rice. In South Korea, Japan, and Thailand, surplus rice displaced commonly used feed grains, such as corn and wheat, and the governments of those countries found it necessary to price rice appropriately to compete with these alternative grains.

Using the USDA-ERS baseline model, this report found that the effect on the global rice market of China implementing a feed rice policy could be small. If China diverts surplus rice into the feed market, increasing the amount yearly until reaching an annual release of 10 million mt, the global rice price increases by 2 percent by the year 2028, according to the simulation, regardless of whether corn is displaced domestically (assumption 1) or via import restrictions (assumption 2). Because of the decline in rice stocks, China's rice imports increase and its rice exports significantly decrease. However, China accounts for less than 3 percent of total world exports.

The model simulation also shows that if rice is substituted for corn from China's corn stocks, domestic corn absorbs the policy shock, and the effect on the global corn price is trivial. As a result, corn imports by other nations increase only slightly. However, if the substitution of rice for corn occurs from corn imports, and China imposes a restriction akin to Thailand's wheat-import controls, the global market is more responsive. In the simulation results, if China replaces corn imports, the global corn market reacts to the lower prices by increasing demand for corn.

Not long ago, it would have been surprising to see governments employing feed markets to liquidate rice stocks. This policy is no longer rare and warrants additional data and study. As our modeling exercise shows, diverting just a small amount of China's stocks to feed can affect trade flows. Further segmentation of rice-use data can aid future analysis by tracking trends in feed rice use and further illuminating the impact of feed rice on traditional feed crops. Reflecting this point, several USDA, Foreign Agricultural Service posts have recently included data on the use of rice for feed in their Global Agricultural Information Network (GAIN) grain and feed updates.

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Appendix

Table A

Protein and lysine content of cereal grains

Crop	Metabolizable energy, poultry (kcal/lb)	Metabolizable energy, swine (kcal/lb)	Crude protein (%)	Lysine (%)
Barley	1,250	1,305	11.50	0.53
Yellow corn	1,540	1,520	7.50	0.24
Corn gluten feed	795	1,090	21.00	0.60
Oats	1,160	1,215	11.00	0.47
Rice (rough)	1,335	1,075	7.30	0.24
Rice bran (unextracted)	925	1,000	13.50	0.50
Sorghum	1,505	1,470	11.00	0.27
Sorghum (gluten feed)	975	1,200	42.00	0.80
Soybean meal	1,020	1,405	44.00	2.70
Soybean meal (dehulled)	1,115	1,425	47.80	3.02
Wheat (hard)	1,440	1,465	13.50	0.40
Wheat bran	590	1,055	14.8	0.60

Note: Crude protein is a measurement of nutrient content per unit, calculated as mineral nitrogen content times 6.25. Lysine is typically the first limiting amino acid in feed rations. Unextracted rice bran has not gone through the oil-removal process. Soybean meals assume an organic solvent process.

Source: Batal et al. (2012).