Import Protections in China's Grain Markets: An Empirical Assessment

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Abstract

In 2016, the United States launched a trade dispute against China at the World Trade Organization over its tariff quota administration for imports of three grain commodities: maize, rice and wheat. To inform policymakers and stakeholders involved in this dispute, this article quantifies the effects of the tariff quota administration on China's grain imports from its major trading partners. We estimate the import demand elasticities using a source differentiated model and the monthly trade data during 2013-2017, while accounting for tariff and expenditure endogeneities. We then perform counterfactual analysis and find that China's grain imports could have been 1.2 billion dollars or 38% higher than observed in 2017. The imports from the United States, especially of wheat, would have also significantly increased. We also find that the tariff quota administration acts as an import variable levy in China's rice and wheat markets, and it seems to be an adjunct to the domestic price support policy that aims to keep domestic prices high.

Keywords: Tariff quota administration, grain markets, China, import restriction, trade policy.

1 Introduction

In December 2016, the U.S. launched a dispute request against China at the World Trade Organization (WTO) over its tariff quota administration for imports of three grain commodities: maize, rice and wheat. In the request statement, the U.S. claimed that "China has failed to ensure that the administration of Tariff Rate Quotas (TRQs) would not inhibit the filling of quotas" (USTR, 2016). Meanwhile, the U.S. Department of Agriculture (USDA) estimated that China's grain imports could have increased by 3.5 billion dollars in 2015 if the quotas were fully utilized, indicating high impacts of the tariff quota administration on trade (USTR, 2016). Other major grain exporters to China, including Canada and Australia, have requested to join the proceedings of the dispute as third parties. In September 2017, the WTO dispute settlement body established a panel to deal with the dispute. To date, the dispute has not yet been settled (WTO, 2018).

The trade dispute highly concerns the U.S. government as it has been recognized as a major agricultural trade policy issue for the U.S. 115^{th} congress (McMinimy et al., 2017). China has become the predominant market for U.S. agricultural exports since 2012 (Hansen et al., 2017). According to USDA trade statistics, 34% of bulk commodity exports from the U.S. were destined for China in 2016 (USDA, 2017). Given the high export share, China's import restrictions could cause significant losses to U.S. agricultural exporters and producers. As noted by Michael Froman, the former U.S. trade representative:

> "China's TRQ policies breach their WTO commitments and limit opportunities for U.S. farmers to export competitively priced, high-quality grains to customers in China. ... The U.S. will aggressively pursue this challenge on behalf of American rice, wheat, and corn farmers." (USTR, 2016)

To inform policymakers and stakeholders involved in this dispute, this article empirically assess the impacts of the tariff quota administration on China's grain imports from its major trading partners. This analysis demonstrates the economic interests of individual countries, including the U.S., against those of China in the dispute. It also illustrates the potential economic outcomes of grain trade liberalization by China that might occur at the following times.

Our work makes two contributions to the literature. First, few empirical studies have examined the grain imports in China. This is probably due to the fact that China did not start consistently importing grains until 2012 (Gale, Hansen, and Jewison, 2015). We use the recent-year trade data to estimate a key structural parameter – the import demand elasticity. Different to many other studies, we account for the policy impacts when deriving the elasticity estimates. With these, we show how China's grain imports would respond to changes in prices under different policy environments.

Second, many empirical studies focused on tariff reduction or quota expansion when examining the economic impacts of TRQ liberalization (e.g. Grant, Hertel, and Rutherford, 2009). We, in contrast, focus on tariff quota administration, another element of the TRQ policy that could also inhibit the market access and restrict trade (Skully, 2001; Abbott, 2002; Mönnich, 2003; Li and Carter, 2005; de Gorter and Kliauga, 2006). The related empirical works are limited in numbers because the trade effects of tariff quota administration are often implicit and hard to disentangle from effects of other trade policy instruments. In China's grain markets, the tariff quota administration has been used as the main policy instrument for regulating trade. It provides us an opportunity to look into the tariff quota administration. Besides, our empirical results would be valuable to the policymakers and trade negotiators involved in the dispute.

We begin with calculating the ad valorem tariff equivalents of the tariff quota administration to measure its price impacts (Deardorff and Stern, 1997; Ferrantino, 2006). The data for calculating them are from reports of the Chinese government. The reports consist of monthly product-specific wholesale prices, domestic or imported, at a particular port. The prices account for transportation costs, taxes and duties. With these attributes, we can calculate for the tariff equivalents simply by comparing the reported domestic and imported prices. Then we transform the price impacts into quantity impacts using the import demand elasticity. To obtain the elasticity, we model China's grain imports from its major trading partners in one demand system. The demand system accounts for substitution effects across grain commodities and countries. We estimate the model using monthly trade data during 2013-2017, a unique period in which China consistently imported grains at large scale from certain countries. We also model the tariff and expenditure endogeneity to derive consistent elasticity estimates.

We find that the tariff quota administration in China has significantly restricted its grain imports. Our counterfactual analysis suggest that China's total imports of maize, rice and wheat would have been 1.8 billion dollars, or 38% higher than the observed in 2017, had the tariff quota administration not been import-restrictive. Meanwhile, China's grain imports from the U.S. could be 314 million dollars higher in 2017. Our analysis also indicates that the way that China administered its grain quotas has lowered the price competitiveness of foreign grain exporters in China.

In the following section, we provide a background on the TRQ policy in China's grain markets. We develop a theoretical model within a partial equilibrium framework to demonstrate the trade effects of tariff quota administration in section 3. Section 4 presents the empirical models used to estimate the effects. Section 5 describes the data and section 6 discusses the results. The final section proceeds to conclusion and discusses the policy implications.

2 Background on China's TRQ policy

TRQ is a two-tier tariff system: the first-tier tariff rate is applied to in-quota imports and a relatively higher second-tier tariff is applied to out-of-quota imports. China introduced the TRQ schedule into its grain markets during its WTO accession in 2001. Initially, the quota limits were set at 8.47 million tonnes for wheat, 5.85 million tonnes for maize and 3.99 million tonnes for rice. In 2004, the quota limits were increased to 9.6 million tonnes, 7.2 million tonnes and 5.3 million tonnes accordingly (Zhou and Kang, 2007), and they have not been changed since then. The rice quota is divided equally to long grain rice and to short and medium grain rice. The in-quota tariff rate for most grain products is 1%, but the out-of-quota tariff rate is 65%.[1]

The quotas are administrated by China's National Development and Reform Commission. The government agency is responsible for assigning quotas to the quota applicants. Notably, the majority proportions of quotas – 90% for wheat, 60% for maize quotas and 50% for rice – are reserved to the State Trading Enterprises (STEs). The remaining quotas are for the private firms on a "first-

[1] Table S-1 in the appendix provides the tariff rates by products of Harmonized System at eight digits. All section, table or figure references that have an "S" preceding the number are contained in the supplementary appendix.

come, first-serve" and "historical performance" basis. Besides, all firms, including the STEs, shall return the unused quotas by mid-September. The returned quotas are supposed to be redistributed to those applied.

In the dispute statement, the U.S. argued that China is not appropriately administering the reallocation process, causing quota underfill. To shed light on this argument, we plot the quota fill rates for maize, rice and wheat during 2004-2017 in figure 1. We see that the quotas for the three grain commodities have never been filled since 2004. The quota fill rates were around 80% at their highest levels. Furthermore, the quota fill rates were constantly low before 2012. This was likely caused by weak import demand. Otherwise, the quota fill rates should have been at least higher than the quota shares allocated to private firms in the first place. The quota fill rates were substantially increased after 2012 as the grain imports started to rise. The rates for rice steadily increased to around 80% in 2017. For maize and wheat, the rates range from 30% to 60% at most times. Hence, the key problem is whether the grain imports after 2012 would have been higher than observed – so the quotas were filled – if the quota administration were not import-restrictive.

The last thing to note is that the TRQ policy is operated against the background that China has implemented price support policy for grain commodities for around two decades. The policy aims to increase farmers' income and to promote domestic production (Huang and Yang, 2017). Under the policy, the government purchases grains from farmers with support prices and then retains them for public storage (Gale, 2013; Huang and Yang, 2017). A striking consequence of the policy is the massive grain stocks. According to USDA, China's stocks-to-use ratios are 43% for maize, 61% for rice and 94% for wheat in 2016. The high stocks induced high fiscal costs, motivating the government to adjust and reform its price support policy (Huang and Yang, 2017). In 2016, China replaced the price support program with a pilot subsidy program for maize. In 2018, China reduced the support price of wheat for the first time by about 2.6% from 364.8 dollars per tonne.

3 Theoretical consideration

We explore the trade effects of tariff quota policies in the section. Consider a *small* importing country with a TRQ policy under perfect competition. Since the tariff quota administration is a non-tariff barrier, we use the ad valorem tariff equivalent to measure it. In the absence of preference shifts, import demand is a function of price (or relative price) and income.

Without losing generality, we specify an import demand function in double log form as follows:

$$\log q = \gamma \log \big[\big(\tau + 1 \big) p^{w} \big] + \beta \log I. \tag{1}$$

where q and p^w denote quantity and price of imports, respectively. The term I denotes income. The parameters γ and β are the effects of price and income on import quantity. The term τ represents ad valorem tariff equivalent (abbreviated as tariff equivalents below) of the tariff quota administration, which contains a fixed component (τ_f) and a variable component (τ_v).

The fixed component reflects the transaction cost associated with the tariff quota administration (Abbott and Morse, 2000; Abbott, 2002); and the variable component is contingent on the import prices for price stabilization. As Abbott (2002) argued,"in most developing countries, tariffs are bound at high levels not to raise applied tariffs, but rather to maintain flexibility in trade regimes. Tariffs can be and are adjusted as world price changes, much like what is accomplished under a variable levy". The variable component reflects parts of the tariff equivalents for the flexible adjustments.

The tariff quota administration in this consideration has two important effects on trade. The first effect is on the import demand elasticity (or own price elasticity of import demand). Taking the first derivative of equation 1 with respect to $\log p^w$ gives the import demand elasticity,

$$\gamma^{*} = \gamma \bigg(1 + \frac{\partial \log \left(1 + \tau \right)}{\partial \log p^{w}} \bigg). \tag{2}$$

Equation 2 indicates that the import demand elasticity decreases in the presence of τ_v, assuming $-1 < \frac{\partial \log(1+\tau)}{\partial \log p^{w}} < 0$. Equation 2 also indicates that the fixed component, τ_f, does not affect import demand elasticity. In fact, the term γ can also be interpreted as import demand elasticity if the tariff equivalent τ or its variable component τ_v is absent. We then call it unrestricted import demand elasticity and γ^* the restricted import demand elasticity.

The second effect is on the import quantity. We can show that the tariff quota administration causes the import quantity to decline by,

$$\Delta \log q = -\gamma \log \big(1 + \tau\big). \tag{3}$$

Equation 3 indicates that the reduced quantity is simply the product of its tariff equivalents and the *unrestricted* import demand elasticity (see figure S-1).

4 Empirical framework

We use the price data reported by the Chinese government to directly calculate the price effects of the tariff quota administration. Here we demonstrate how we estimate the import demand elasticity and use the elasticity estimates to transform the price effects into quantity effects.

4.1 The import demand model

We use a source differentiated Almost Ideal Demand System (AIDS) to estimate the import demand elasticity, a model that was frequently used in the literature to analyze the import demand (Yang and Koo, 1994; Carew, Florkowski, and He, 2004; Henneberry and Hwang, 2007; Wan, Sun, and Grebner, 2010).

The model specification is as follows:

$$w_{i_h,t} = \alpha_{i_h} + \sum_j \sum_k \gamma_{i_h j_k} \log \big[\big(\tau_{j,t} + 1\big) p_{j_k,t}\big] + \beta_{i_h} \log \big(E_t / P_t\big) + \boldsymbol{\delta_{i_h} D_t} + \epsilon_{i_h,t}. \tag{4}$$

where the subscript i_h denotes the commodity i imported from country h. Similarly, the subscript j_k denotes the commodity j imported from country k. The imports of a commodity might be from different countries. The subscript t denotes time. The dependent variable w denotes the import share or budget share ($\sum_i \sum_h w_{i_h,t} = 1$). The independent variables consist of import price (p), total expenditure or total import value (E), and a price index (P). The notation $\boldsymbol{D}$ represents a vector of variables, including seasonality and policy. The term ϵ denotes residuals. The parameters to be estimated are α, β, γ and $\boldsymbol{\delta}$. There are three theoretical restrictions on the parameters:

$\sum_i \sum_h \alpha_{i_h} = 1, \sum_i \sum_h \gamma_{i_h j_k} = 0, \sum_i \sum_h \beta_{i_h} = 0$ for adding up, $\sum_j \gamma_{ij} = 0$ for homogeneity and $\gamma_{ij} = \gamma_{ji}$ for symmetry. Notably, the term τ denotes the commodity-specific tariff equivalents of tariff quota administration. For notational simplicity, we let $\tau^*_{j,t} = \tau_{j,t} + 1$.

The price index is proxied by a simplified loglinear analogue of the Laspeyres price index (Moschini, 1995):

$$\log P_t = \sum_i \sum_h w^0_{i_h} \log \big(\tau^*_{i,t} p_{i_h,t}\big). \tag{5}$$

where $w^0_{i_h}$ is a base share, which is measured by average budget shares during the sampling period. Although Moschini (1995) suggested several other proxies of the price index, we choose this one for two major reasons. First, this index does not include the independent variable w_{i_h}, so that simultaneity issue can be avoided (Moschini, 1995). Second, the simple structure of the index allows us to derive a tractable expression for the price elasticity.

The own price elasticity of import demand (or import demand elasticity) for the model specified above is as follows:[2]

$$\eta^*_{i_h i_h,t} = \Bigg[-1 + \frac{1}{w_{i_h,t}} \bigg(\gamma_{i_h i_h} + \beta_{i_h} w^0_{i_h} \Big(\frac{d \log E_t}{d \log P_t} - 1 \Big) \bigg) + \frac{d \log E_t}{d \log P_t} w^0_{i_h} \Bigg] \bigg(1 + \frac{d \log \tau^*_{i,t}}{d \log p_{i_h,t}} \bigg). \tag{6}$$

Section S-1 in the appendix shows the derivations. The formula above is similar to equation 2. As discussed before, the term $\eta^*_{i_h i_h,t}$ is restricted import demand elasticity because it is affected by the tariff equivalents. The term in square brackets is unrestricted import demand elasticity, which is denoted as $\eta_{i_h i_h,t}$.

Note that there are two terms that cannot be estimated by the import demand model. The first term is $\frac{d \log \tau^*_{i,t}}{d \log p_{i_h,t}}$, which is elasticity of tariff equivalents with respect to import prices. If the tariff quota administration acts as an import variable levy, the tariff equivalents would be negatively associated with imports prices and the elasticity term would be negative (yet larger than -1). In this case, the restricted import demand elasticity is less than the unrestricted import demand elasticity in absolute value. The second term is $\frac{d \log E_t}{d \log P_t}$, which is elasticity of total expenditure with respect

[2]By forcing $\frac{d \log \tau_{i,t}}{d \log p_{i_h,t}}$ to be zero, the expression collapses to the formula that is derived by Thompson (2004) (equation 11 at page 4), which accounts for the endogeneity of group expenditure.

to import prices. The literature has highlighted the importance of considering this term, because it directly affects the import demand elasticity (Davis and Jensen, 1994; Thompson, 2004). Next, we describe strategies for estimating the two terms in turn.

4.2 Response of tariff equivalents to import prices

We specify the following equation to indirectly estimate the elasticity of the tariff equivalents with respect to import prices:

$$\log \tau^*_{i,t} = a^0_i + a^1_i \log PI_{i,t} + \epsilon'_{i,t}. \tag{7}$$

where PI is a commodity-specific Laspeyres price index. It is defined as: $\log PI_{i,t} = \sum_h w^1_{i_h} \log p_{i_h,t}$, where $w^1_{i_h}$ is average budget share for a product within a commodity group.

Estimating equation 7 might encounter a simultaneity issue. Specifically, import prices ($p_{i_h,t}$) used to calculate $PI_{i,t}$ could be correlated with the world prices that are used to calculate $\tau_{i,t}$, since both measure the prices of imported goods, through defined in different ways. The import price is unit import value, and world price is the CIF price of foreign goods. This correlation might make the two variables, $\tau^*_{i,t}$ and $PI_{i,t}$, simultaneously determined to some extent, biasing the estimate of a^1_i. To alleviate this issue, we use the export prices of exporting countries to instrument import prices.

Our interest is in the parameter a^1_i, through which we obtain the value of the elasticity of the tariff equivalents with respect to import prices. Note that the term is commodity-specific, so each grain commodity has unique value. Specifically, we have

$$\frac{d \log \tau^*_{i,t}}{d \log p_{i_h,t}} = \frac{d \log \tau^*_{i,t}}{d \log PI_{i,t}} \frac{d \log PI_{i,t}}{d \log p_{i_h,t}} = \tilde{a}^1_i w^1_{i_h}. \tag{8}$$

where $\tilde{a}^1_i$ is the estimated value of a^1_i.

4.3 Response of expenditure to import prices

In order to estimate the elasticity of expenditure with respect to import prices, we need to consider the first-stage allocation problem, i.e., the decision of choosing expenditure to spend on grain imports. The literature has proposed different control variables for empirical analysis, such as per capita income and consumer price index from the consumer theory perspective (Thompson, 2004), as well as output and input prices (e.g. wage and capital rental rate) from the production theory perspective (Muhammad, Jones, and Hahn, 2007; Muhammad, McPhail, and Kiawu, 2012). Because we do not have monthly data for these variables, we utilize the panel structure of the data to control for these variables. The objective is to minimize the risk of omitting important variables while using the least number of extra variables.

We begin with specifying the reduced form equation below to estimate the elasticity of the commodity-specific expenditure ($E_{i,t}$) to a commodity-specific import price index ($P^X_{i,t}$).

$$E_{i,t} = b_0 + b_1 \log P^X_{i,t} + b_2 \log P^O_{i,t} + \mu_i + \nu_t + \epsilon''_{i,t}. \tag{9}$$

where $E_{i,t}$ denotes the group expenditure allocated to imports of commodity i at time t ($\sum_i E_{i,t} = E_t$). The term $P^X_{i,t}$ is a commodity-specific import price index, and $\log P^X_{i,t} = \sum_h w^0_{i_h,t} \log\left(\tau^*_{i,t} p_{i_h,t}\right)$. We define the price index in this way to obtain a closed form for derive the expenditure elasticity. The term P^O denotes output price, which is measured by retail prices of corresponding commodities in China. The output price for maize is the price of pork, because the imported maize in China is mainly used as livestock feed. We rely on the commodity dummy (μ_i) to control for market characteristics. The time dummy (ν_t) can control for per capita income and consumer price index, because they are commodity invariant.

The expenditure elasticity is dependent on the parameter b_1 (see section S-2 for derivations). Specifically, we have

$$\frac{d \log E_t}{d \log P_t} = \frac{b_1}{E_t}. \tag{10}$$

4.4 Simulating the import quantity

Having obtained the value of $\frac{d \log E_t}{d \log P_t}$, we are able calculate the unrestricted import demand elasticity based on equation (6). Then we use the elasticity estimates to simulate the quantity impacts of the tariff quota administration. With reference to Kastens and Brester (1996) (equation 8 on page

304), we use the following formula to simulate the import quantity assuming that tariff quota administration were not import-restrictive:

$$q^*_{i_h,t} = \left[\sum_j \sum_k \eta_{i_h j_k} \left(\frac{1}{\tau_{i,t}} - 1 \right) + 1 \right] q_{i_h,t}. \tag{11}$$

where $\eta_{i_h j_k}$ is *unrestricted* import demand elasticity. The term q denotes observed import quantity, and q^* denotes the simulated import quantity. This formula is similar to equation (3) except that the elasticity of substitution is considered here.

5 Data and descriptive analysis

5.1 Price data and the tariff equivalents

We obtain price data from March 2013 to December 2017 through the "Monthly Bulletin of Agricultural Demand and Supply Statistics" (unofficial translation), an economics report regularly released by China's Ministry of Agriculture (MOA). It contains monthly wholesale prices of both domestic and imported grain commodities at specific ports. The commodity prices are of those sharing similar qualities or grades. Maize prices, for instance, are prices of No.2 yellow maize both for domestic and imported. In addition, the prices account for transportation costs, tariffs and taxes (see table S-2 for details). Given the data attributes, the domestic prices and imported prices from the report are comparable, so we can directly calculate tariff equivalent based on their differences. The tariff equivalents can be attributed mostly to the tariff quota administration, because, as far as we know, there exists no other relevant import barrier for the grain commodities in China. The price data during 2009-2013 are from another database - the China Grain website.[3] Figure S-2 displays the price data.

The tariff equivalents in China's grain markets have dramatically changed in recent years. Figure 2 illustrates the annual tariff equivalents for wheat (dashed line), rice (dotted line) and maize (solid line) from 2009 to 2017. It shows that the tariff equivalents of the three grain commodities were constantly negative during 2009-2013 and are positive after 2013. This means that the tariff

[3] The website address is `http://datacenter.cngrain.com`

quota administration was not import-restrictive until 2013. The figure also shows that the tariff equivalents for maize and rice reached their maximum values in 2015. So, in this year, the tariff quota administration is most import restrictive for them. The situation for maize changed in 2016. Since then, the domestic maize price kept declining and converged to the world maize price in the end of 2017 (see figure S-2), resulting in a much lower tariff equivalent. It was also about the time that China ended the price support program for maize. The tariff equivalent of wheat was highest in 2016 and then moderately decreased to around 40% in 2017.

5.2 Trade data and import shares

We obtain trade data from January 2009 to December 2017 through the "Monthly Bulletin of Agricultural Trade Statistics" (unofficial translation), a statistical report that is regularly released by China's Ministry of Commerce. The report contains data on China's imports from its top three trading partners at monthly basis, both in quantities and in values. The annual trade data starting from 1992 are from the UN Comtrade database.

Considering that we are estimating a source differentiated trade model, it is useful to examine the distribution of China's import shares among its trading partners. Table 1 reports China's grain imports, in values, from its top three exporters in 2016. We see that China sourced its grain imports mostly from two or three countries. For instance, China imported nearly 90% of maize from two countries, Ukraine and the U.S.. Likewise, over 90% of the import shares for wheat and rice are concentrated in three countries. Specifically, Australia, Canada and the U.S. were major sources of wheat imports; Vietnam, Thailand and Pakistan were major sources of wheat imports. We only show the 2016 data here; however, the highly concentrated import shares have been persistent over time, at least over the study period (see figure S-3 if interested).

6 Results

In this section, we begin with reporting the estimation results for equation (4), equation (7) and equation (9). Then, we report the estimated impacts of the tariff quota administration on import quantities and import demand elasticity.

6.1 Model estimates

When estimating equation (4), we let Ukraine and the U.S. be source countries for maize; Vietnam, Thailand and Pakistan for rice; and Canada, Australia and the U.S. for wheat. These countries have been consistently exporting grains to China over the study period. Ukraine is an exception because it did not export maize to China from January 2013 to November 2013. So the import prices of Ukrainian maize are not observed in that period. We impute them by multiplying Ukraine's export prices of maize by 1.65, an average markup ratio. The zero imports could be driven by some non-price factors, so we include the dummy to control for those, which has significant value. We use the iterated seemingly unrelated regression method to estimate the equation, while imposing the theoretical restrictions of homogeneity and symmetry on it to achieve better out-of-sample forecasts (Kastens and Brester, 1996; Muhammad, Jones, and Hahn, 2007). The coefficient estimates are reported in table S-3.

Table 2 reports the results for estimating equation (7). The estimated parameters without instruments are -0.79 and -0.74 for rice and wheat, respectively; the estimated parameters with instruments are -1.79 and -0.97 instead. The differences indicate that the simultaneity issue could have biased our parameter estimates. Nevertheless, the negative parameter estimates suggest that the tariff quota administration has worked as an import variable levy in Chinas rice and wheat markets. When the prices of imported grains decline, the tariff quota administration would become more import-restrictive to prevent the costs of importing grains from decreasing. For instance, according to the parameter estimates, the tariff equivalents of wheat would increase by 0.33% if the U.S. wheat prices were to decrease by 1%. [4] In other words, 33% of the price effects on imports would be mitigated by the endogenous adjustments on the import restrictions.

The parameter estimate for maize is not statistically significant. The result is not surprising. As aforementioned, China has ended the price support program for maize in 2016, suggesting that the Chinese government might be no longer interested in intervening the maize prices. Otherwise, we would not see the slump of domestic maize price that started in early 2015 (figure S-2). In

[4] Evaluated at average values of import shares, the elasticities of tariff equivalents with respect to import prices for other countries are -0.59 for Thailand rice, -0.98 for Vietnam rice, -0.22 for Pakistan rice, -0.39 for Australia wheat, and -0.25 for Canada wheat.

this case, it would be unnecessary to exercise the tariff quota administration as an import variable levy. Indeed, trade polices are often adjuncts of domestic policies in agriculture. The domestic price support policy in China cannot be effective without executing a trade policy that divorces the domestic price from world prices. On the contrary, regulations on trade would be pointless when domestic market is liberalized.

Table 3 reports the regression results for equation (9). The parameter estimate for the import price index significantly changes once the market and time dummy variables are included in the model. This signals the importance of controlling for the market-specific and time-specific effects. With the estimates, the elasticity of expenditure with respect to import prices is -0.87. This indicates that consumers in China allocate more expenditure on imported grains when they are cheaper. Specifically, the total grain imports, in values, increases by 0.87% when the import price index declines by 1%.

6.2 Policy effects on imports

Figure 3 displays the simulated China's grain imports in 2017, the most recent year to date, had the tariff quota administration not been import-restrictive (zero tariff equivalents). The bars in light grey represent the observed import quantities; the bars in dark grey represent the simulated import quantities. The error bars represent 90% confidence intervals, and the uncertainties are inherited from the parameter estimates in the import demand model. We see that the imports of maize and wheat could have been 1.8 and 2.5 million tonnes, or 69% and 61% higher than observed, respectively. The rice was less affected by the tariff quota administration, since its imports could have been 14% higher. This is due to the low import demand elasticity associated with it. Moreover, the simulated import quantities are all lower than the quota limits, meaning that the grain quotas were unlikely to be filled. In figure S-4, we convert the quantities into values using the average import prices in 2017. We find that, in sum, the grain imports would be 1.2 billion dollars or 38% higher than observed. At country level, the U.S. wheat exports could have increased by 314 million dollars or 80%, indicating large impacts of the trade regulations by China on U.S. wheat industry. (see figure S-5 and figure S-6 for simulated results by countries).

Figure 4 demonstrates the policy impacts on import demand elasticity. The bars in light grey represent the restricted import demand elasticity; the bars in dark grey represent the unrestricted import demand elasticity. These elasticities are evaluated at historic average values. The error bars represent 90% confidence intervals, which are generated by multivariate Monte Carlo simulations with 5,000 iterations. Notably, the import demand for Thai rice, Australian wheat and U.S. wheat are much less elastic under the import restriction. This means that, for these goods, the imports would increase to much less extent if they were to become cheaper. Consequently, grain producers in China would face less import competitions from foreign countries.

7 Conclusions

In 2016, the U.S. launched a trade dispute against China at the WTO over the tariff quota administration for imports of grain commodities. To inform the policymakers and stakeholders involved in the dispute, we quantify the impacts of the tariff quota administration on China's grain imports from its major trading partners using the most recent trade data. Our analysis shows that the tariff quota administration has significant restrictive effects on grain imports. Specifically, China's grain imports in 2017 could have been 1.2 billion dollars or 38% higher than observed; however, the quotas were unlikely to be filled. To the U.S., its wheat exports were negatively affected to a large extent. Besides, the tariff quota administration in China's wheat and rice markets works as an import variable levy, lowering the import competition faced by the domestic producers. Importantly, it seems to be an adjunct of the domestic price support policy that aims to keep domestic prices high.

A policy implication of our findings is that policy makers and negotiators might focus on China's wheat market. China has undertaken a major step towards agricultural liberalization – abolishing the price support program – in the maize market in 2016. After that, the price gap of maize diminished rapidly and finally disappeared in the end of 2017. In the rice market, there is less demand for import restriction because the foreign products are not highly price competitive. The wheat market has a different scenario. The price gap remains high, and foreign wheat products, especially that from the U.S. and Australia, are price competitive in China. Moreover, China has built massive stocks of wheat, of which are hard to dispose. It is also fiscally costly to maintain. Hence, trade liberalization in the wheat market could be highly challenging to China at the current stage.

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8 Tables and Figures

8.1 Tables

Table 1: Distribution of China's import shares among top three trading partners by grain commodities in 2016. Note: The data are sourced from China's Ministry of Commerce.

Commodity	Country	Import value (million USD)	Import share (%)
Maize	Ukraine	501.9	79.5
	U.S.	55.9	8.8
	Laos	40.8	6.5
	Subtotal	631.7	94.8
Wheat	Australia	326.3	40.2
	Canada	214.6	26.4
	U.S.	205.1	25.3
	Subtotal	811.5	91.9
Rice	Vietnam	733.9	45.5
	Thailand	490.3	30.4
	Pakistan	249.6	15.5
	Subtotal	1613.1	91.4

Table 2: Regression of the tariff equivalents of tariff quota administration on import price indices. Notes: The dependent variable is log of commodity-specific tariff equivalents of tariff quota administration. The 3SLS regression uses indices of the export prices of exporting countries as instruments. The export prices are sourced from the FAO GIEWS database. The data range from January 2013 to December 2017. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

	SUR			3SLS		
	Maize	Rice	Wheat	Maize	Rice	Wheat
Log price index	0.03	-0.79^{***}	-0.74^{***}	-1.83	-1.79^{***}	-0.97^{***}
	(0.05)	(0.13)	(0.07)	(2.83)	(0.27)	(0.11)
R^2	0.02	0.38	0.55	–	–	–
Obs.	60	60	60	60	60	60

Table 3: Regression of commodity specific import expenditures (in million dollars) on commodity-specific import price index. Notes: Numbers in parentheses are robust standard errors clustered by commodity. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

	(1)	(2)	(3)
Import price index	26.1^{***}	-178.5^{*}	-223.7^{**}
	(0.7)	(101.3)	(113.2)
Log of retail price	3.5^{***}	26.5	-47.7
	(0.7)	(77.4)	(51.5)
Month dummies	No	No	Yes
Commodity dummies	No	Yes	Yes
R^2	0.12	0.14	0.47
F statistics	12.2^{***}	7.4^{***}	1.6^{**}
	(df = 2, 177)	(df = 4, 175)	(df = 63, 116)
Obs.	180	180	180

8.2 Figures

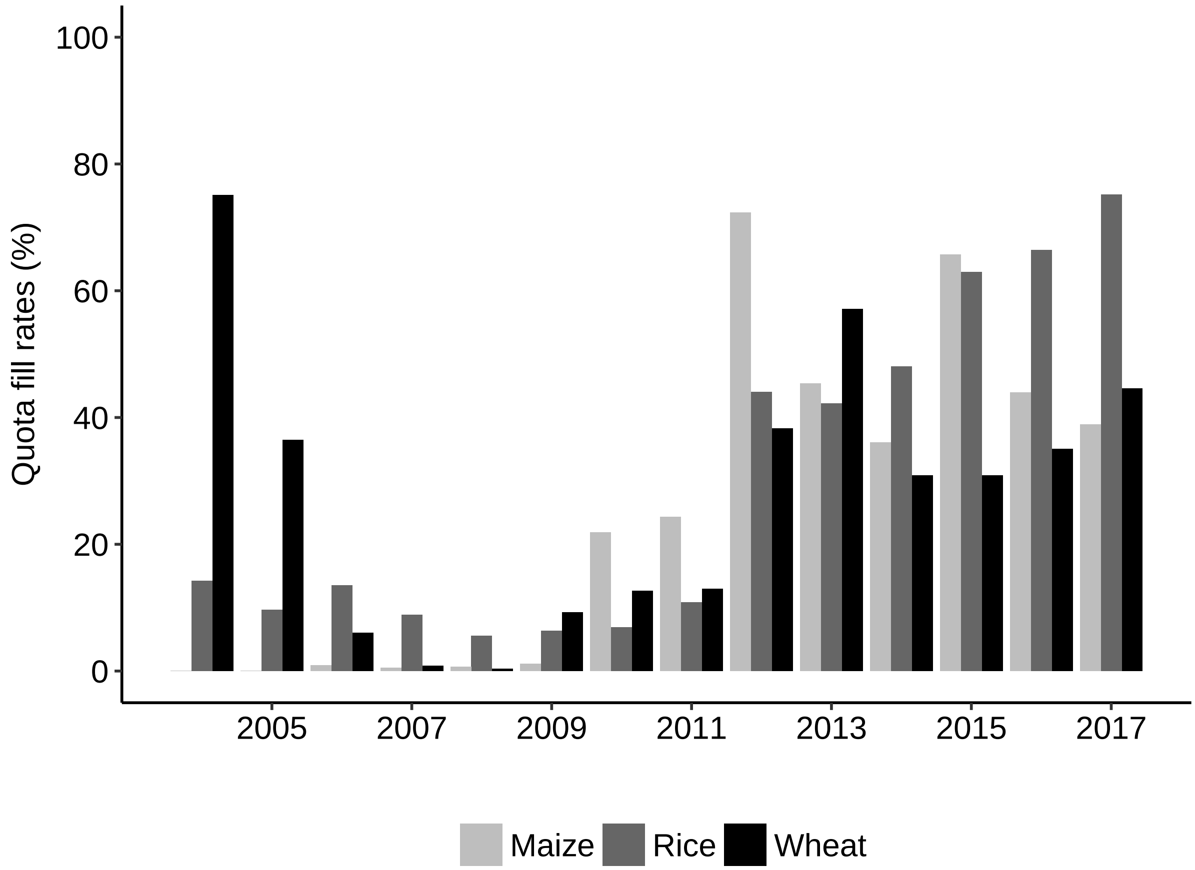

Figure 1: China's quota fill rates for maize (*left*), rice (*middle*), wheat (*right*) from 2004 to 2017. Notes: Quota fill rates are the annual import quantities divided by the committed quota limits. The quota limits are 9.636, 7.2 and 5.32 million tonnes for wheat, maize and rice respectively. The data before 2016 are from the UN Comtrade database. The 2017 data are from China's Ministry of Commerce

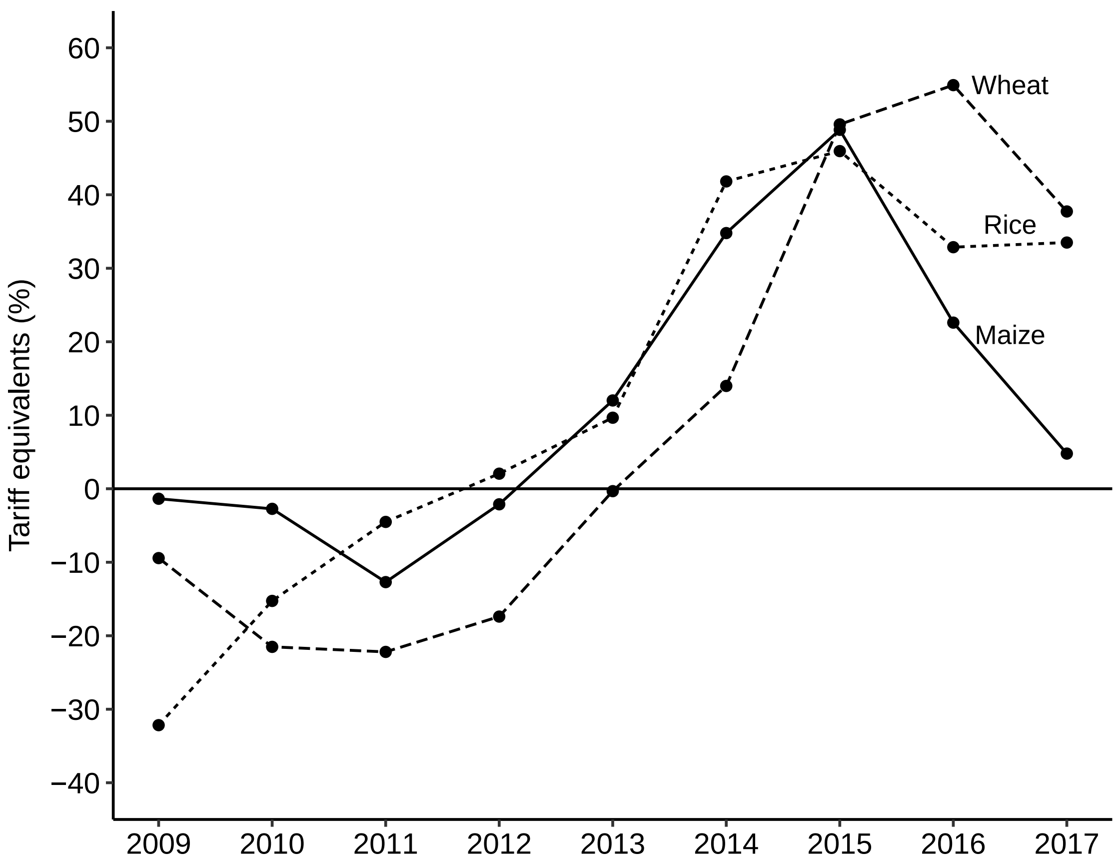

Figure 2: Tariff equivalents of tariff quota administration for grain commodities in China during 2009-2017. Notes: The price data are sourced from the Ministry of Agriculture of China and the China Grain website.

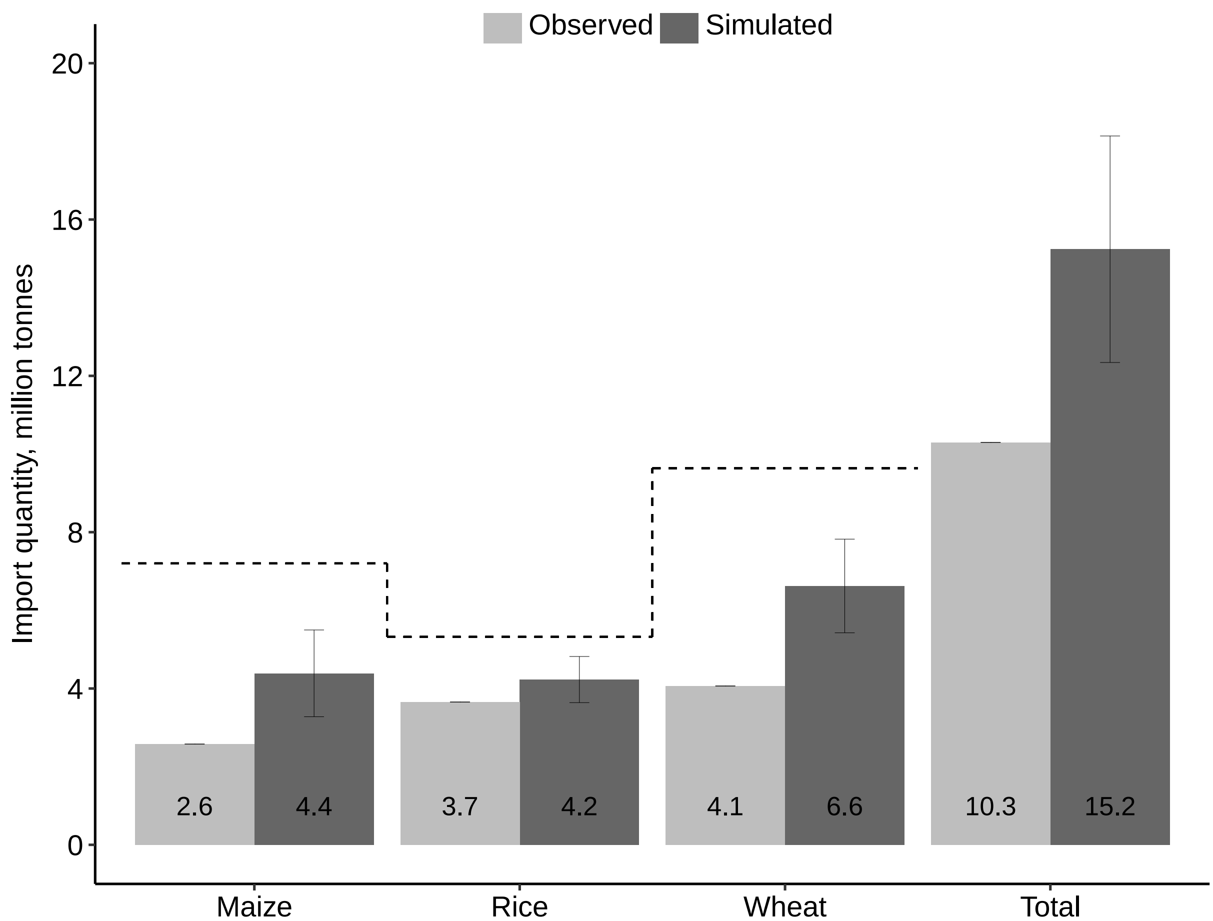

Figure 3: Simulation of China's grain imports (in quantities) in 2017, had the tariff quota administration no been import-restrictive. Notes: The light grey bars, labeled as "Observed", represent the observed import quantities. The dark grey bars, labeled as "Simulated", represent the simulated import quantities. The numbers are noted at the bottom of the bars. The error bars represent the 90% confidence interval of the estimates. The dashed lines represent the quota limits.

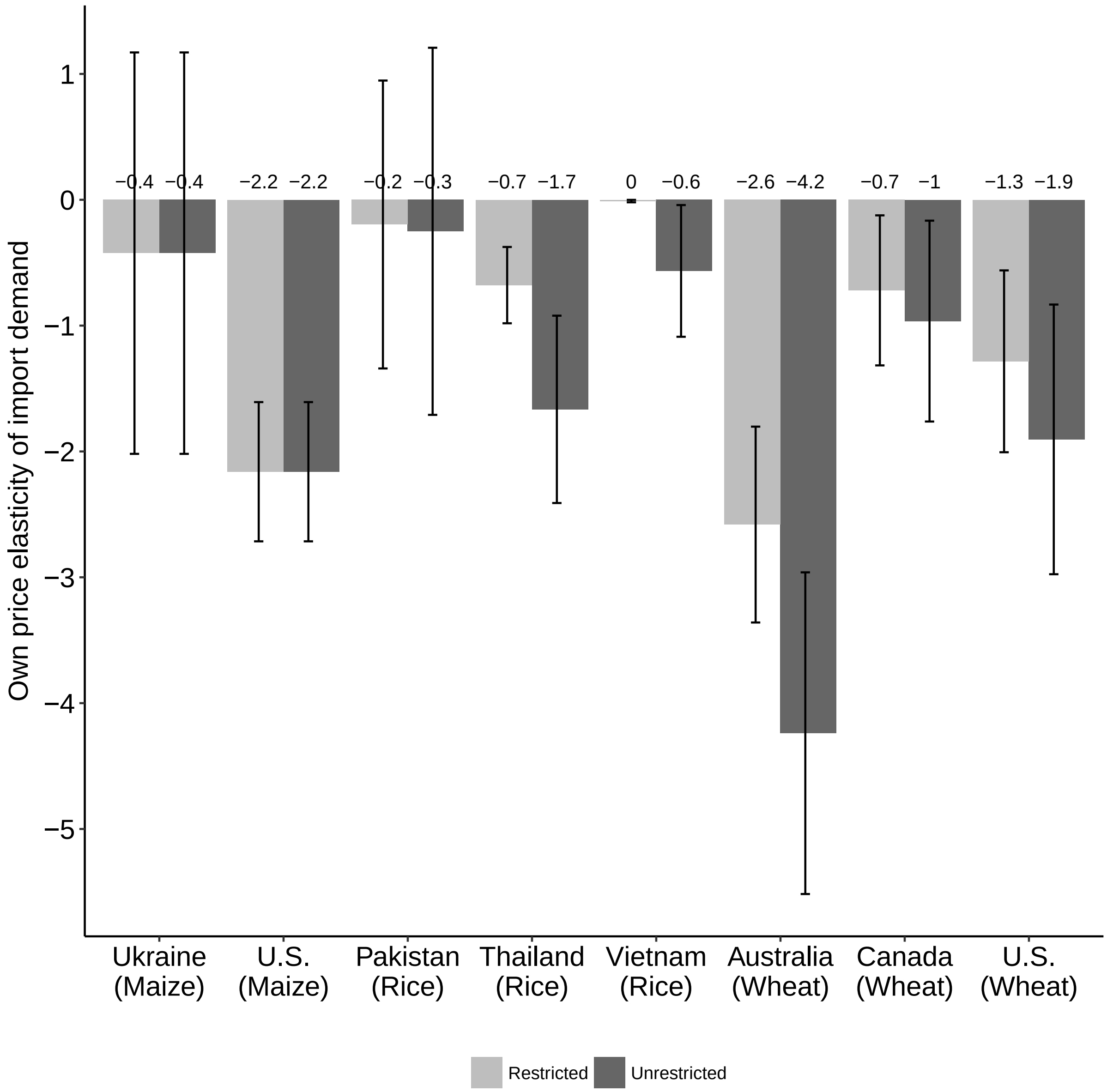

Figure 4: Estimates of restricted and unrestricted own price elasticity of import demand by commodity and source country. The error bars are confidence intervals at 90% significance level.

Appendix

Appendix S-1 Deriving price elasticities in the SDAIDS Model

To derive for the price elasticity of import demand, we first consider the definition of the budget share. The time subscript is omitted here for notational simplicity.

$$w_{i_h} = \frac{\tau_i^* p_{i_h} q_{i_h}}{E}. \tag{S-1}$$

Taking log on both sides and then taking derivatives with respect to $\log p_{j_k}$ returns

$$\frac{d \log w_{i_h}}{d \log p_{j_k}} = \frac{d \log \tau_i^*}{d \log p_{j_k}} + \delta_{i_h j_k} + \frac{d \log q_{i_h}}{d \log p_{j_k}} - \frac{d \log E}{d \log p_{j_k}}. \tag{S-2}$$

where $\delta_{i_h j_k}$ is the Kronecker delta. It equals 1 when $i = j$ and $h = k$ and 0 otherwise. Our goal is to calculate the price elasticity of demand, which is the third term on the right-hand side. So we rearrange the terms to get

$$\frac{d \log q_{i_h}}{d \log p_{j_k}} = -\delta_{i_h j_k} - \frac{d \log \tau_i^*}{d \log p_{j_k}} + \frac{d \log w_{i_h}}{d \log p_{j_k}} + \frac{d \log E}{d \log p_{j_k}}. \tag{S-3}$$

Next, we evaluate the first term on the right-hand side. We shall refer to equation 4 in the main text to get its value. We expand the log terms in equation 4 first,

$$w_{i_h} = \alpha_{i_h} + \sum_j \sum_k \gamma_{i_h j_k} \Big(\log \tau_j^* + \log p_{j_k} \Big) + \beta_{i_h} \Big(\log E - \log P \Big) + \boldsymbol{\delta_{i_h} D_t} + \epsilon_{i_h}. \tag{S-4}$$

Taking the derivative of the above equation with respect to $\log p_{j_k}$ returns,

$$\begin{aligned} \frac{d w_{i_h}}{d \log p_{j_k}} &= \gamma_{i_h j_k} \Big(\frac{d \log \tau_j^*}{d \log p_{j_k}} + 1 \Big) + \beta_{i_h} \Big(\frac{d \log E}{d \log P} - 1 \Big) \frac{d \log P}{d \log p_{j_k}} \\ &= \gamma_{i_h j_k} \Big(\frac{d \log \tau_j^*}{d \log p_{j_k}} + 1 \Big) + \beta_{i_h} \Big(\frac{d \log E}{d \log P} - 1 \Big) w_{j_k}^0 \Big(\frac{d \log \tau_j^*}{d \log p_{j_k}} + 1 \Big) \\ &= \Big[\gamma_{i_h j_k} + \beta_{i_h} w_{j_k}^0 \Big(\frac{d \log E}{d \log P} - 1 \Big) \Big] \Big(\frac{d \log \tau_j^*}{d \log p_{j_k}} + 1 \Big). \end{aligned} \tag{S-5}$$

From the first step to the second step, we incorporate the fact that $\frac{d\log P}{d\log p_{j_k}} = w^0_{j_k}\left(\frac{d\log \tau^*_{j_k}}{d\log p_{j_k}}+1\right)$ based on the specification of P, i.e. $\log P = \sum_i \sum_h w^0_{i_h} \log\left(\tau^*_i p_{i_h}\right)$. Plugging equation S-5 into equation S-3,

$$
\begin{aligned}
\eta^*_{i_h j_k} &= \frac{d\log q_{i_h}}{d\log p_{j_k}} \\
&= -\delta_{i_h j_k} - \frac{d\log \tau^*_i}{d\log p_{j_k}} + \frac{d\log w_{i_h}}{d\log p_{j_k}} + \frac{d\log E}{d\log p_{j_k}} \\
&= -\delta_{i_h j_k} - \frac{d\log \tau^*_i}{d\log p_{j_k}} + \frac{dw_{i_h}}{d\log p_{j_k}}\frac{1}{w_{i_h}} + \frac{d\log E}{d\log P}\frac{d\log P}{d\log p_{j_k}} \\
&= -\delta_{i_h j_k} - \frac{d\log \tau^*_i}{d\log p_{j_k}} + \frac{1}{w_{i_h}}\left[\gamma_{i_h j_k} + \beta_{i_h} w^0_{j_k}\left(\frac{d\log E}{d\log P}-1\right)\right]\left(1+\frac{d\log \tau^*_{i_h}}{d\log p_{j_k}}\right) + \frac{d\log E}{d\log P} w^0_{j_k}\left(1+\frac{d\log \tau^*_j}{d\log p_{j_k}}\right) \\
&= -\delta_{i_h j_k} - \frac{d\log \tau^*_i}{d\log p_{j_k}} + \left[\frac{1}{w_{i_h}}\left(\gamma_{i_h j_k} + \beta_{i_h} w^0_{j_k}\left(\frac{d\log E}{d\log P}-1\right)\right) + \frac{d\log E}{d\log P} w^0_{j_k}\right]\left(1+\frac{d\log \tau^*_j}{d\log p_{j_k}}\right).
\end{aligned}
\tag{S-6}
$$

The above equation gives the formula for calculating own and cross price elasticity of import demand with the Laspeyres price index. In particular, the own price elasticity is ($i = j$ and $h = k$),

$$
\eta^*_{i_h i_h} = \left[-1 + \frac{1}{w_{i_h}}\left(\gamma_{i_h i_h} + \beta_{i_h} w^0_{i_h}\left(\frac{d\log E}{d\log P}-1\right)\right) + \frac{d\log E}{d\log P} w^0_{i_h}\right]\left(1+\frac{d\log \tau^*_i}{d\log p_{i_h}}\right). \tag{S-7}
$$

The above equation is the same as to equation 6 in the main text, except for that the time subscript is omitted here.

Appendix S-2 Deriving the elasticity of aggregate expenditure to price index

The elasticity of aggregate expenditure to price index is $\frac{d\log E_t}{d\log P_t} = \frac{a_1}{E_t}$. Define $E_{i,t}$ as the group expenditure, so we have $E_t = \sum_i E_{i,t}$. Also, define $\log P_{i,t} = \sum_h w^0_{i_h,t} \log \tau^*_{i,t} p_{i_h,t}$ and then $\log P_t = \sum_i \sum_h w^0_{i_h,t} \log \tau^*_{i,t} p_{i_h,t} = \sum_i \log P_{i,t}$. Then, we have

$$\begin{aligned}\frac{d\log E_t}{d\log P_t} &= \frac{1}{E_t}\frac{dE_t}{d\log P_t} \\ &= \frac{1}{E_t}\frac{d\sum_i E_{i,t}}{d\sum_i \log P_{i,t}} \\ &= \frac{1}{E_t}\frac{\sum_i dE_{i,t}}{\sum_i d\log P_{i,t}}. \qquad \text{(S-8)}\end{aligned}$$

As specified by equation 9, $\frac{dE_{i,t}}{d\log P_{i,t}} = b_1$ for $\forall i$. Alternatively, $dE_{i,t} = b_1 d\log P_{i,t}$. Plugging this into the above equation,

$$\frac{1}{E_t}\frac{\sum_i dE_{i,t}}{\sum_i d\log P_{i,t}} = \frac{1}{E_t}\frac{\sum_i a_1 d\log P_{i,t}}{\sum_i d\log P_{i,t}} = \frac{b_1}{E_t}. \qquad \text{(S-9)}$$

Hence,

$$\frac{d\log E_t}{d\log P_t} = \frac{b_1}{E_t}. \qquad \text{(S-10)}$$

Appendix S-3 Price data management

The monthly data of domestic prices and imported prices for calculating the tariff equivalents are mainly from China's Ministry of Agriculture (abbreviated as MOA). As noted in the main text, the data only start from March 2013. However, we need to know the prices before 2013 to calculate the tariff equivalents at the time, even through they are not needed for the regressions.

We then resort to another database – the China Grain website (`http://datacenter.cngrain.com`), to obtain the monthly price data from January 2009 to December 2014. We compare the data in the overlapping period (from March 2013 to December 2014) from the two sources; we find that they overlap and are highly correlated. Yet, the wheat prices from the two sources differ in levels; probably because of that they report prices of wheat in different qualities. We treat the MOA data as benchmark and then shift the data from the China Grain website, either by adding a constant or multiplying a constant to them, depending on which method produces the lowest sum of squared. We use the Kalman filter based on the state space representation of the ARIMA model, an efficient and consistent method for time series data imputation (Harvey and Pierse, 1984), to impute for the missing values. The finally obtained price data are illustrated in figure S-2.

Appendix S-4 Additional tables and figures

Table S-1: Import tariff rates in percentages for wheat, maize and rice products by Harmonized Schedule eight-digits in China. Notes: the most-favored-nation (MFN) tariff for 10064010 and 10064090 products are reduced from 65% to 10% in December 2017. Data source: `http://www.qgtong.com/hgsz/ShowArticle.asp?ArticleID=44121`

Commodity	HS code	Common tariff	MFN tariff	In-quota tariff
	10011100	180	65	1
	10011900	180	65	1
	10019100	180	65	1
Wheat	10019900	180	65	1
	11010000	130	65	6
	11031100	130	65	9
	11032010	180	65	10
	10051000	180	20	1
	10059000	180	65	1
Maize	11022000	130	40	9
	11031300	130	65	9
	11042300	180	65	10
	10061011	180	20	1
	10061019	180	65	1
	10061091	180	65	1
	10061099	180	65	1
	10062010	180	65	1
	10062090	180	65	1
	10063010	180	65	1
Rice	10063090	180	65	1
	10064010	180	65	1
	10064090	180	65	1
	11029011	130	40	9
	11029019	130	40	9
	11031921	70	10	9
	11031929	70	10	9

Table S-2: Definition of the price series of grain commodities reported by Ministry of Agriculture of China.

	Domestic prices	World prices
Maize	Exit price at *Huangpu* port in Guangzhou of No.2 yellow maize shipped from northeastern China	Price of U.S. No.2 yellow maize shipped from the gulf of Mexico at *Huangpu* port in Guangzhou after duties and taxes
Wheat	Price of high quality wheat at *Huangpu* port in Guangzhou	Price of U.S hard red winter wheat from the gulf of Mexico at *Huangpu* port in Guangzhou after duties and taxes
Rice	Average wholesale price of No.1 late Indica rice	Price of Thai white long grain rice (25% broken) at *Huangpu* port in Guangzhou after duties and taxes

Note: *Huangpu* port is one of the biggest marine transportation centers in southern China.

Table S-3: Regression results of the source differentiated AIDS model. Notes: The dependent variable is budget share (or import share). The model is estimated by the iterated seemingly unrelated regression method. The time trend is excluded because it is insignificant. The equation for wheat from Canada is omitted here because of singularity. The impute dummy is 1 if there was no maize imported from Ukraine (UKR) and 1 otherwise. The policy dummy is 1 if the year is after 2015 and 0 otherwise. *p<0.1; **p<0.05; ***p<0.01

	Maize		Rice			Wheat	
	USA	UKR	THI	VIN	PAK	USA	AUS
Log price of	−0.07***	0.01	0.02	-0.03	0.02	0.07**	-0.01
USA maize	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)
Log price of	0.01	0.09	-0.03	−0.09	−0.01	−0.12*	0.12*
UKR maize	(0.03)	(0.1)	(0.05)	(0.06)	(0.04)	(0.07)	(0.06)
Log price of	0.02	-0.03	−0.11*	0.12**	-0.02	-0.01	0.09
THI Rice	(0.02)	(0.05)	(0.07)	(0.05)	(0.04)	(0.04)	(0.06)
Log price of	-0.03	−0.09	0.12**	0.09	-0.06	-0.05	0.11*
VIN rice	(0.03)	(0.07)	(0.05)	(0.08)	(0.04)	(0.05)	(0.06)
Log price of	0.02	−0.01	-0.02	-0.06	0.05	0.02	0.03
PAK rice	(0.01)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.05)
Log price of	0.07**	−0.12*	-0.05	-0.09	0.02	-0.06	0.02
USA wheat	(0.03)	(0.07)	(0.04)	(0.05)	(0.03)	(0.08)	(0.05)
Log price of	−0.01	0.12*	0.09	0.11*	0.03	0.02	−0.38***
AUS wheat	(0.02)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.09)
Log price of	−0.01	0.02	-0.06	−0.09**	-0.03	0.15***	0.01
CAN wheat	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Log of	0.1**	0.08*	−0.09***	−0.17***	0	0.14***	-0.04
real income	(0.03)	(0.05)	(0.02)	(0.03)	(0.02)	(0.05)	(0.03)
Impute	0.06***	−0.06***	–	–	–	–	–
dummy	(0.02)	(0.02)					
Policy	−0.08***	0.13**	0.02	0.03	0.01	−0.17***	0.07**
dummy	(0.03)	(0.05)	(0.03)	(0.04)	(0.02)	(0.05)	(0.03)
Quarterly dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	60	60	60	60	60	60	60
R^2	0.53	0.32	0.59	0.43	0.29	0.43	0.41
D.W.	1.51	0.99	1.39	1.27	1.24	1.32	1.32

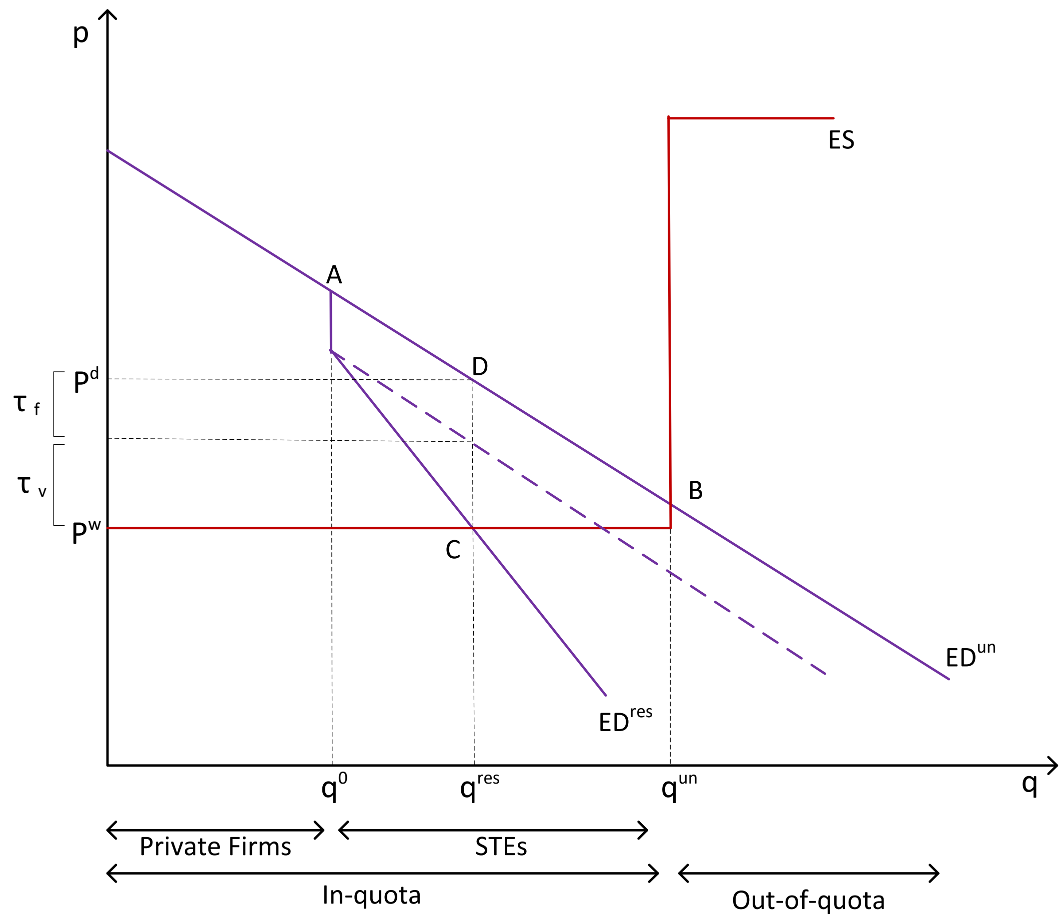

Figure S-1: Graphical illustration of the theoretical model described in section 3. Notes: The ED^{un} curve represents the import demand curve in the absence of the restrictive tariff quota administration. In its presence, the import demand curve shifts downwards because of the fixed component of the tariff equivalent, and then rotates inwards because of the variable component, becoming the ED^{res} curve. The two terms τ_f and τ_v represent the fixed and variable components of the tariff equivalent of tariff quota administration, respectively. The excess supply curve is represented by ES. The term q^0 denotes the quotas available to private agents. The import quantities are denoted as q^{un} (unaffected by import restriction) and q^{res} (affected by import restriction). The prices are denoted as p^d (domestic price) and p^w (world reference price).

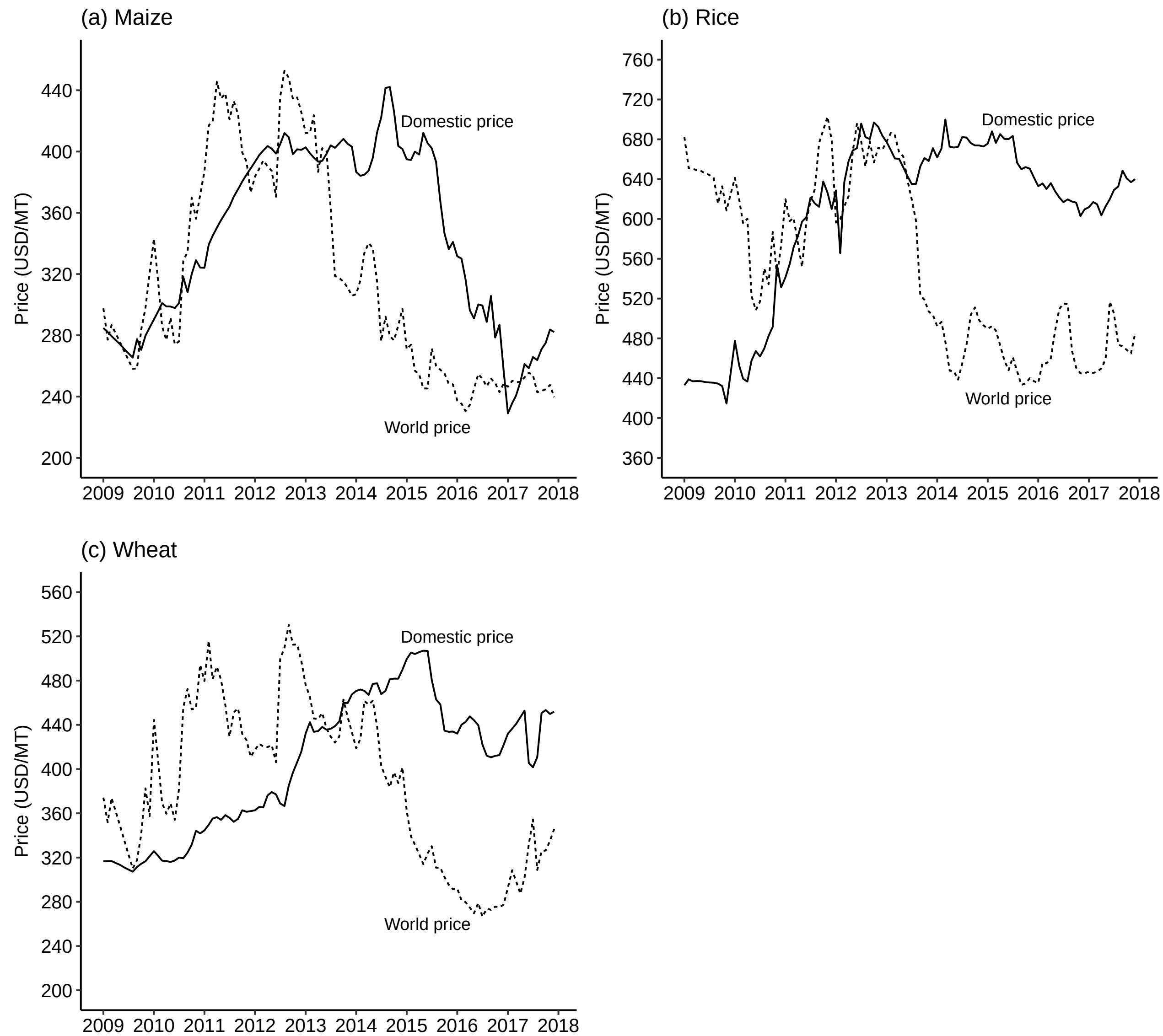

Figure S-2: Monthly domestic and world prices for maize (a), rice (b) and wheat (c) in China from January 2009 to December 2017. Notes: The price data are sourced from China's Ministry of Agriculture and the China Grain website. The exchange rates from the IMF are used to convert the price units into U.S. dollars.

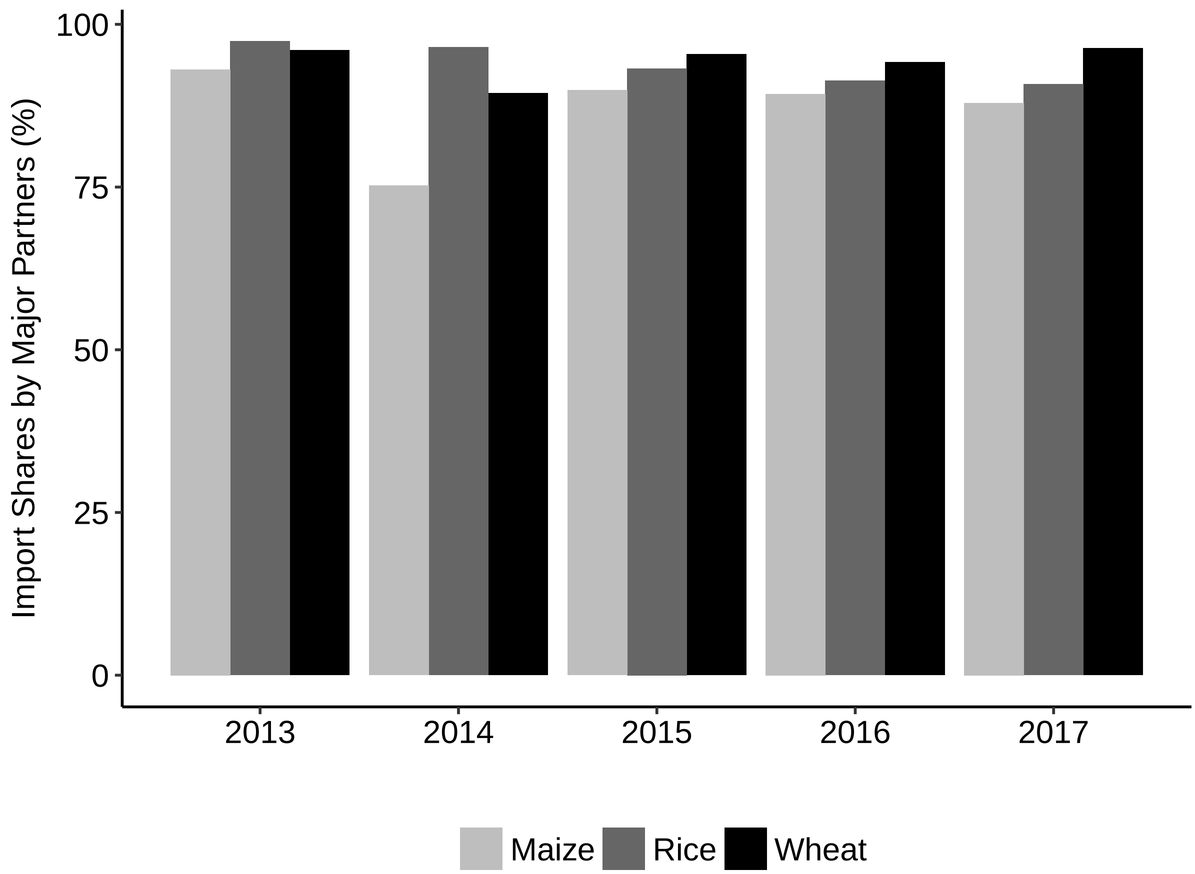

Figure S-3: China's share of imports from its major trading partners by grain commodity during 2013-2017. Notes: the major trading partners are the U.S. and Ukraine for maize; Vietnam, Thailand and Pakistan for rice; Australia, Canada and the U.S. for wheat. The data are from China's Ministry of Commerce.

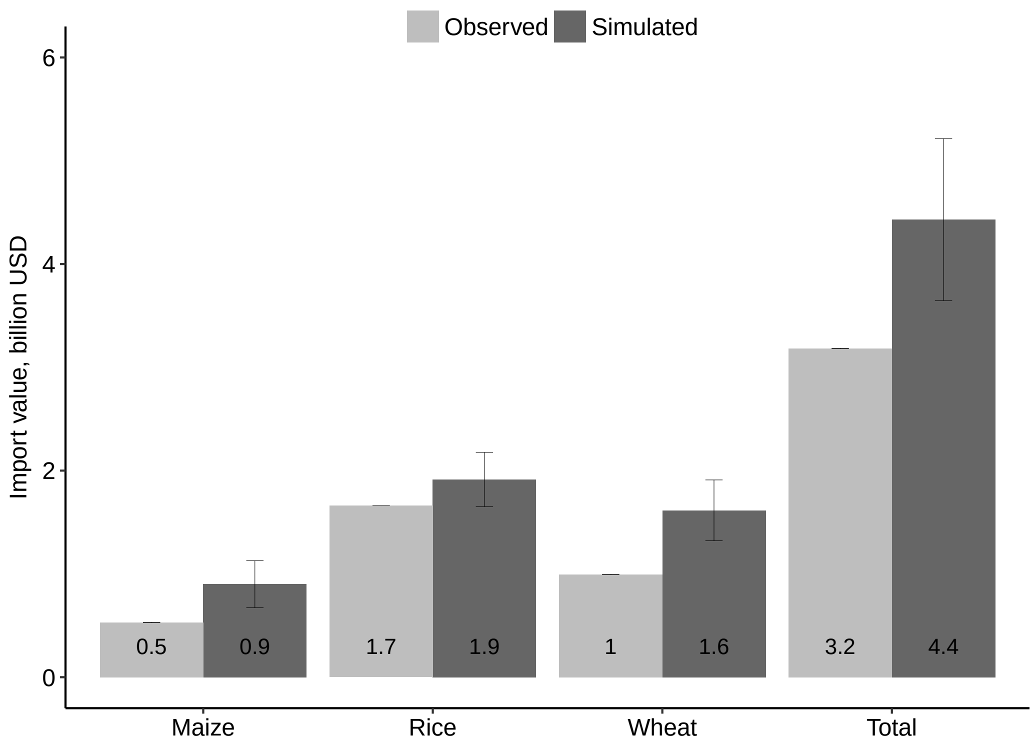

Figure S-4: Simulation of China's grain imports (in values) in 2017, had the tariff quota administration no been import-restrictive. Notes: The import values are products of import quantities and average import prices in 2017. The light grey bars, labeled as "Observed", represent the observed import quantities. The dark grey bars, labeled as "Simulated", represent the simulated import quantities. The numbers are noted at the bottom of the bars. The error bars represent the 90% confidence interval of the estimates.

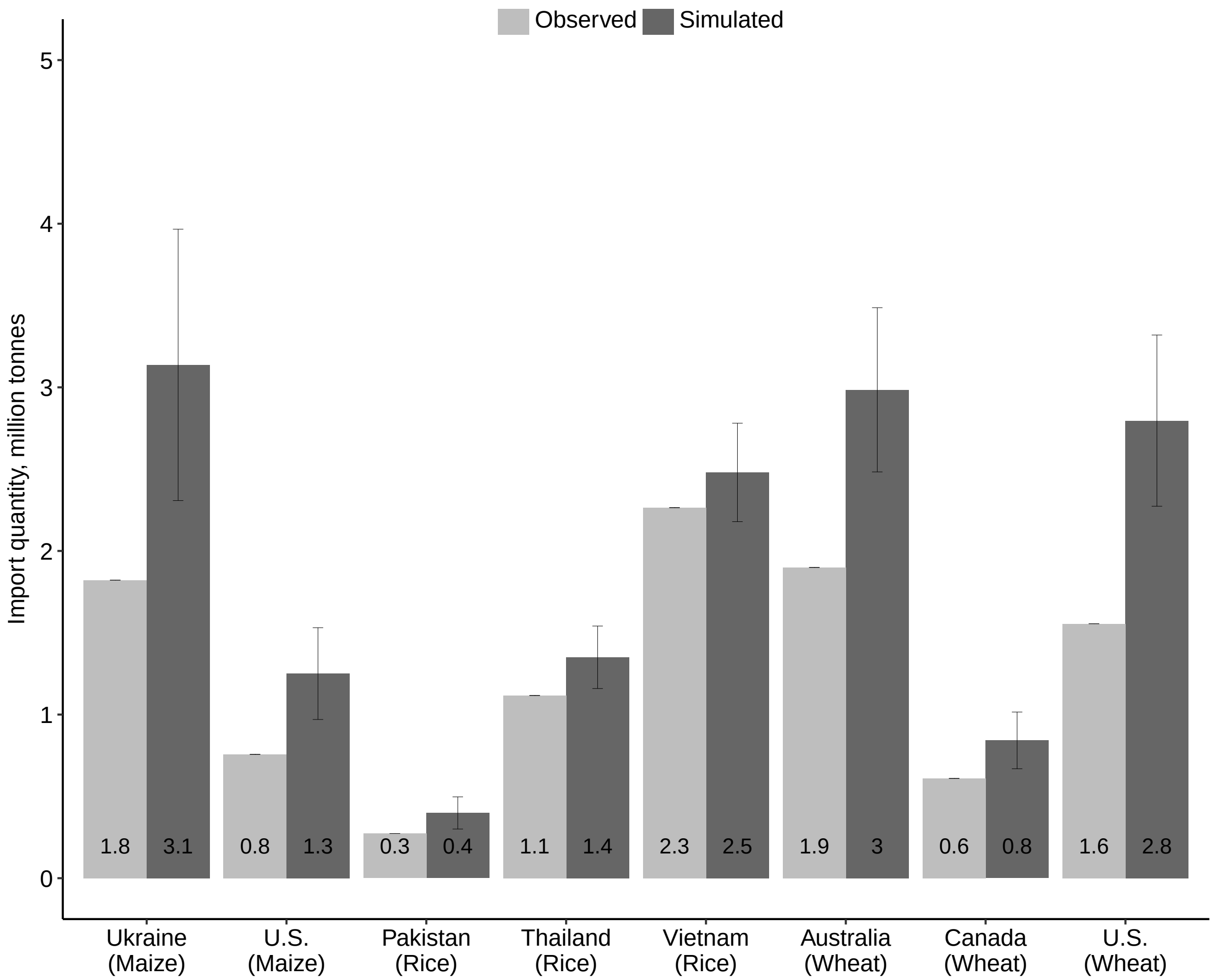

Figure S-5: Simulation of China's grain imports (in quantities) in 2017 by source country, had the tariff quota administration no been import-restrictive. Notes: The import values are products of import quantities and average import prices in 2017. The light grey bars, labeled as "Observed", represent the observed import quantities. The dark grey bars, labeled as "Simulated", represent the simulated import quantities. The numbers are noted at the bottom of the bars. The error bars represent the 90% confidence interval of the estimates.

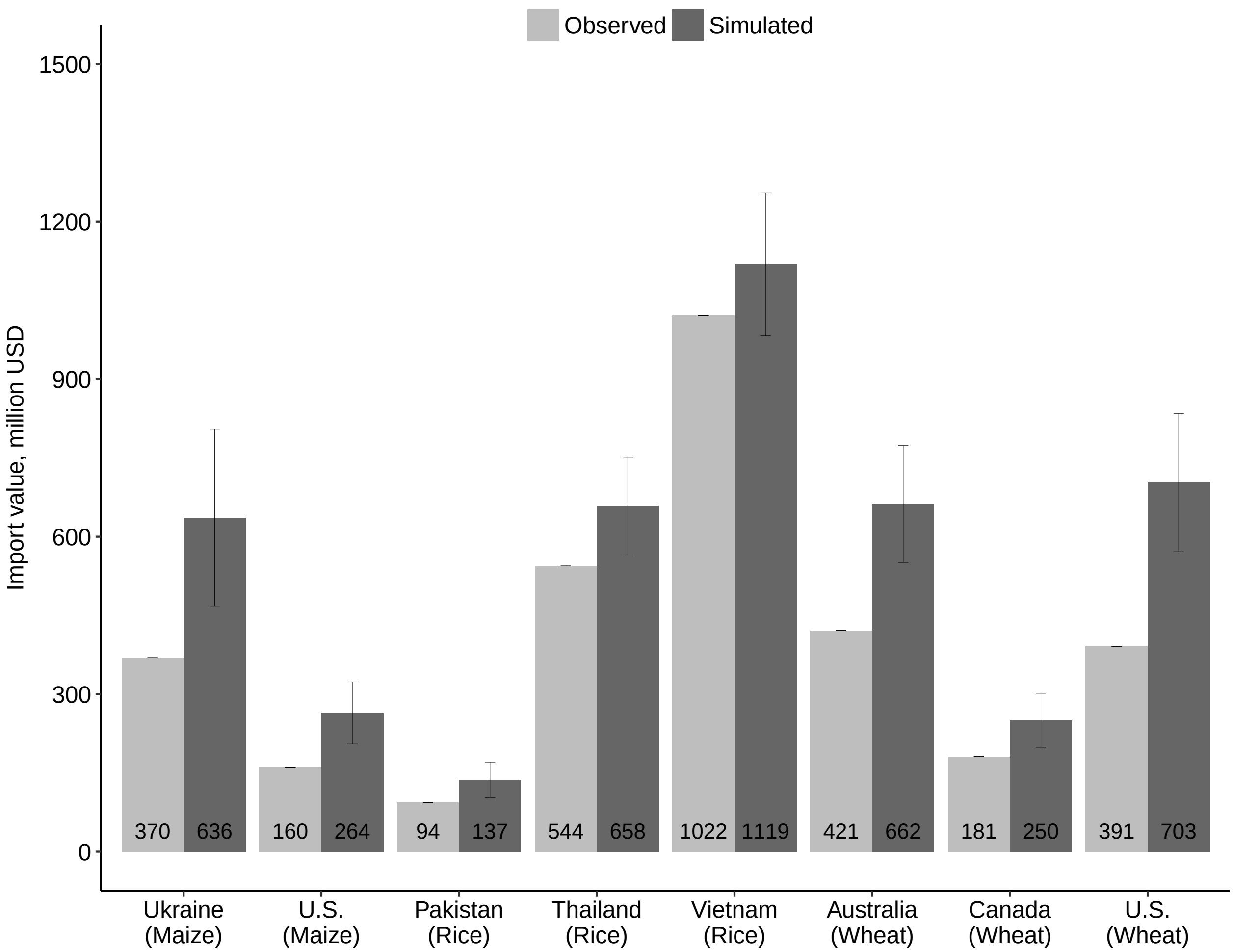

Figure S-6: Simulation of China's grain imports (in values) in 2017 by source country, had the tariff quota administration no been import-restrictive. Notes: The import values are products of import quantities and average import prices in 2017. The light grey bars, labeled as "Observed", represent the observed import quantities. The dark grey bars, labeled as "Simulated", represent the simulated import quantities. The numbers are noted at the bottom of the bars. The error bars represent the 90% confidence interval of the estimates.