China's Import Demand for Agricultural Products: The Impact of the Phase One Trade Agreement

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May 28, 2021

Abstract

In December 2019, China committed to purchase more imports from the United States under a Phase One trade agreement. We show that the most efficient way for China to increase its agricultural imports from the United States is to mimic the effect of an import subsidy, which would need to be 42% and 59%, respectively, to meet the 2020 and 2021 targets in the absence of other growth from 2017. As a result, China would divert agricultural imports away from other countries, especially from Australia and Canada, followed by Brazil, Indonesia, Malaysia, Thailand and Vietnam.

We thank participants at the NBER conference "Agricultural Markets and Trade Policy," April 30-May 1, 2020, and the 2019 annual meeting of the International Agricultural Trade Research Consortium (IATRC), December 8-10, 2019, for their comments. This research was supported by Cooperative Agreement 58-3000-7-0087 between the U.S. Department of Agriculture's Economic Research Service and the University of California at Davis. The findings and conclusions in this article are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy. All calculations for this paper are available in the zip file "Feenstra-Hong-Phase One", posted at: http://www.robertcfeenstra.com/papers.html.

1. Introduction

Since joining the World Trade Organization (WTO) in 2001, China has become a major agricultural importer. In Figure 1 we report China's agricultural imports from the United States and from the rest of the world (ROW).[1] These values peaked in about 2014 and remained quite high in 2017, when China's agricultural imports from the United States totaled $24.1 billion.[2] Since that time, however, U.S. agricultural exports to China fell to $13.2 billion in 2018 and $16.3 billion in 2019. That reduction in China's imports from the United States was due in part to the ongoing trade war, with China applying restrictions on agricultural imports and other goods in response to U.S. tariffs on imports from China (Carter and Steinbach, 2020).

In December 2019, the United States and China reached a Phase One agreement to relieve the trade tensions that started in 2018 under President Trump. Under this agreement, China committed to purchase more imports from the United States (Bown, 2020). Specifically, as compared with 2017 agricultural imports of $24.1 billion, the Phase One agreement creates targets of $36.6 billion in 2020 and $43.6 billion in 2021, as shown in Figure 1. In fact, during 2020, Chinese agricultural imports from the United States were $23.5 billion, or just 64% of the commitment.[3] While the coronavirus pandemic in 2019-21 and the election of President Biden may render this agreement moot or at least delay its implementation,[4] it is still worth asking whether it could have been achieved.

We show in this paper that the *most efficient* way for China to import more from the United

[1] In Figure 1 we report values up to 2017 from China Customs data, as discussed in the Online Appendix. The values for 2018 and 2019 for U.S. exports to China are for "agricultural and related products" and were obtained from U.S. Census Bureau data compiled by the U.S. Department of Agriculture (USDA).
[2] Chinese customs data indicate imports from the United States of $24.2 billion, while the U.S. data tally U.S. exports to China are $24 billion, so we use $24.1 billion as the 2017 value.
[3] See https://www.piie.com/research/piie-charts/us-china-phase-one-tracker-chinas-purchases-us-goods.
[4] At her Senate confirmation as U.S. Secretary of the Treasury on January 25, 2021, Janet Yellen said that the administration was willing to use the "full array of tools" to influence trade with China. ("Senate Confirms Yellen as Secretary of Treasury", *New York Times,* January 26, 2021, p. A15). It was reported that one of her first tasks would be to review the Phase One agreement.

States is to mimic the effect of an import subsidy on U.S. imports. That is, state agencies could instruct the importers of U.S. agricultural policies to act "as if" there was a subsidy on those goods. For example, if China's agricultural imports grew at the same annual rate from 2017 as during 2007-2017, then we find that the effective subsidies would need to be 12% and 23% to achieve the targets in 2020 and 2021, respectively. But if import growth was only one-half of that amount, then the subsidies would need to be 28% and 41%; if there was no growth from 2017, then the subsidies would need to be 42% and 59%. These subsidy rates for U.S. product are admittedly very high, and it would be challenging to achieve that increase in U.S. imports through state command.

To obtain these results, we estimate a non-homothetic demand system for agricultural imports into China. Standard gravity models derived from a structural relationship are characterized by a constant elasticity of substitution (CES) preferences to describe the demand side of the economy (Anderson and van Wincoop, 2003, Eaton and Kortum, 2002, Chaney, 2008, Arkolakis, Costinot, and Rodríguez-Clare, 2012). However, richer countries often export goods with higher quality and possibly income elasticities (Hallak, 2006, Hallak, 2010, Hallak and Schott, 2011, Feenstra and Romalis, 2014). Recent research emphasizes more flexible non-homothetic demand systems in gravity models. As described in section 2, Fajgelbaum and Khandelwal (2016) have developed a framework that combines an almost ideal demand system (AIDS) defined over products and exporting countries with a gravity equation in trade, so as to identify the demand from each importer for the products from each exporter. The data used to estimate the AIDS-gravity equation consist of imports by 30 Chinese provinces for 58 agricultural commodities from 78 major trading partners, over 1997-2017.

The results of the estimated AIDS-gravity equation are presented in section 3. We distinguish the elasticity of demand by commodity and country of origin with respect to price and income. Based on these key estimated parameters, we are able to forecast China's future import demand for U.S.

agricultural products based on our assumptions about rising spending on imports. We consider three scenarios in section 4: that total spending on all agricultural imports grow at the same annual rate from 2017 as during 2007-2017; that total spending on agricultural imports grows by only one-half that amount; or that there is zero growth in import spending from 2017; and we also allow for various levels of the effective subsidy that China applies on imports from the United States.

In section 5, we solve for the effective subsidies needed to achieve the 2020 and 2021 import targets. While the effective subsidy increases China's purchases from the United States, it diverts its imports away from other countries. That diversion occurs for three reasons: (i) a conventional substitution effect *within* products, which depends on the number of competing countries selling each product in each province; (ii) an income effect that arises due to the effective subsidy, which can offset the substitution effect in part or in whole; and (iii) a further substitution effect that can occur *across* products, particularly as some expenditure shares in the AIDS system reach zero so that there is a renormalization of all other demand shares. Countries experiencing a fall in their exports to China due to the effective subsidy on the United States would be justified in raising a complaint to the WTO. We find that this trade diversion is especially strong for Australia and Canada, followed by Brazil, Indonesia, Malaysia, Thailand, and Vietnam, and then Argentina, France, Germany, Netherlands, and New Zealand. Section 6 concludes, and the data sources and additional results are included in the Online Appendix.

2. AIDS and the Gravity Equation

We begin with Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) defined over products n and countries i importing from countries j:

$$S_{ij}^{n} = \frac{X_{ij}^{n}}{Y_i} = \alpha_{ij}^{n} + \sum_{n'} \sum_{j'} \gamma_{jj'}^{nn'} \ln p_{ij'}^{n'} + \beta_j^n y_i, \qquad (1)$$

where $S_{ij}^n = \frac{X_{ij}^n}{Y_i}$ is the share of aggregate expenditure in country *i* allocated to product *n* from country *j*, and $\sum_n \sum_j S_{ij}^n = 1$ for each importer *i*. X_{ij}^n stands for value of exports from exporter j to importer i in sector n, and Y_i is the total expenditure of importer i. We follow Fajgelbaum and Khandelwal (2016) in referring to the importers *i* as countries, but later we specialize them to be China's provinces. On the right-hand side, α_{ij}^n is a parameter influencing the expenditure share, $p_{ij'}^{n'}$ are the prices of all the products n' imported from countries j', with substitution parameters $\gamma_{jj'}^{nn'}$, while y_i denotes the log of "real income" of importer *i*, with parameters β_j^n indicating possibly non-homotheticity in demand for the product *n* purchased from country *j.* As is common in AIDS estimation, real income can be measured incorporating an income distribution across consumers, so that it becomes:

$$y_i = \left[\ln\left(\frac{\bar{x}_i}{a_i}\right) + IN_i\right], \tag{2}$$

where: $\ln a_i = \sum_n \sum_j \alpha_{ij}^n \ln p_{ij}^n + \frac{1}{2} \sum_n \sum_j \sum_{n'} \sum_{j'} \gamma_{jj'}^{nn'} \ln p_{ij}^n \ln p_{ij'}^{n'}$ is the homothetic price index in country *I*; $\bar{x}_i$ is the mean of the income distribution; and IN_i is the Theil index of income inequality.

To reduce the number of parameters that need to be estimated, Fajgelbaum and Khandelwal (2016) assume that the substitution parameters $\gamma_{jj'}^{nn'}$ are highly symmetric across goods $n = 1,\ldots,N$ and source countries, as follows: equation $\gamma_{jj'}^{nn'} = -(1 - \frac{1}{N})\gamma^n$ for $n = n'$ and $j = j'$; $\gamma_{jj'}^{nn'} = \gamma^n / N$ for $n = n'$ and $j \neq j'$; and $\gamma_{jj'}^{nn'} = 0$ for $n \neq n'$. These assumptions greatly simplify the estimation because there will be a single substitution parameter γ^n for each good.

In order for the expenditures shares in (1) to sum to unity for each importing country *i,* we must have that $\sum_n \sum_j \alpha_{ij}^n = 1$, $\sum_n \sum_j \gamma_{jj'}^{nn'} = 0$ and $\sum_n \sum_j \beta_j^n = 0$, where the summations are taken over all *available* products *n* from countries *j*, selling in each country *i*. The above simplifying assumptions on the $\gamma_{jj'}^{nn'}$ parameters satisfy the condition that $\sum_n \sum_j \gamma_{jj'}^{nn'} = 0$, provided that *N* denotes the number of source countries selling a product in each importer, that is, N_i^n source countries *j*. Likewise, α_{ij}^n and β_j^n need to be adjusted to sum to unity and zero, respectively, over the *available* products in each importing country. These adjustments will become important in our counterfactual exercises later in the paper, as certain regions no longer import some goods. Rather than make this adjustment to the α_{ij}^n and β_j^n parameters explicit in the theory, as a shortcut, we always adjust the *shares to sum to unity* in our counterfactual exercises presented later in the paper.

Under the symmetry assumptions on the $\gamma_{jj'}^{nn'}$ parameters, demand in effect becomes a two-tier system with substitution between goods at the upper level, and substitution between source countries at the lower level, as follows. At the upper level, we can sum equation (1) across all exporters *j* to obtain:

$$S_i^n = \sum_j S_{ij}^n = \overline{\alpha}_i^n + \bar{\beta}^n y_i \qquad (3)$$

where $\overline{\alpha}_i^n = \sum_j \alpha_{ij}^n$, and $\bar{\beta}^n = \sum_j \beta_j^n$. The prices at this aggregate level of total expenditure on good *n* by importer *i* do not appear because we have assumed that the substitution parameters are symmetric and $\gamma_{jj'}^{nn'} = 0$ for $n \neq n'$: that is, demand has constant shares with respect to prices, but the shares still depend on real income. This equation shows how the share of spending on product *n* in each country *i* depends on its real income.

Fajgelbaum and Khandelwal (2016) further aim to eliminate prices at the lower level of aggregation, when there is substitution across supplying countries, for two reasons. First, products imported from different source countries vary by quality, and price reflects quality. Second, trade price data are usually calculated as unit values of trade, which are not actually a reliable indicator of commodity prices. To eliminate prices, they make an assumption that is common in the international trade literature: namely, the international prices p_{ij}^n reflect domestic prices in the exporter p_{jj}^n adjusted for "iceberg" costs of trade, whereby the amount $\tau_{ij}^n \geq 1$ of good *n* must be shipped from country *j* in order for one unit to arrive in country *i*. Formally, this assumption means,

$$p_{ij}^n = p_{jj}^n \tau_{ij}^n \, . \tag{4}$$

Making the various substitutions defined above into (1), we are able to solve for country *j's* domestic prices using the fact that the income of each exporter in sector *n* equals the sales to all countries (including itself) of that product. Using this market clearing condition, we arrive at the following lower-level AIDS in which there is substitution between exporting countries *j* selling to each importer *i*,

$$\frac{X_{ij}^n}{Y_i} = A_{ij}^n + \frac{Y_j^n}{Y_W} - \gamma^n T_{ij}^n + \beta_j^n \Omega_i, \tag{5}$$

where: a) the parameters A_{ij}^n capture cross-country differences in tastes across sectors and exporters are related to α_{ij}^n by:

$$A_{ij}^n = \alpha_{ij}^n - \sum_{i'} \left(\frac{Y_{i'}}{Y_W}\right) \alpha_{ij}^n. \tag{6}$$

b) $\frac{Y_j^n}{Y_W}$ measures the supply capacity of exporter *j*, which is the share of country *j*'s output of product *n* to the world's supply of all products Y_W.

c) T_{ij}^n stands for trade costs, with,

$$T_{ij}^n = \ln\left(\frac{\tau_{ij}^n}{\bar{\tau}_i^n}\right) - \sum_{i'} \left(\frac{Y_{i'}}{Y_W}\right) \ln\left(\frac{\tau_{i'j}^n}{\bar{\tau}_i^n}\right) \text{ and } \bar{\tau}_i^n = \exp[\textstyle\sum_j \ln(\tau_{ij}^n)/N]. \tag{7}$$

d) the term Ω_i again reflects real income adjusted for the Theil index, defined by,

$$\Omega_i = y_i - \sum_{i'=1}^N \left(\frac{Y_{i'}}{Y_W}\right) y_{i'}$$

$$= \left[\ln\left(\frac{\bar{x}_i}{a_i}\right) + IN_i\right] - \sum_{i'=1}^N \left(\frac{Y_{i'}}{Y_W}\right) \left[\ln\left(\frac{\bar{x}_{i'}}{a_{i'}}\right) + IN_{i'}\right] \tag{8}$$

Equation (5) combines features of an AIDS equation and of a gravity equation in trade. The gravity interpretation comes because we have trade costs on the right-hand side. Below we shall assume that trade costs depend on distance. In much the same way as the force of gravity is inversely related to the distance between objects, it is well-established that the amount of trade between countries is inversely related to the distance between them. The AIDS interpretation of this equation come from the non-homothetic component $\beta_j^n \Omega_i$. This component measures the abilities of destination market *i* to purchase imports from various sources, depending on the average real income distribution adjusted by income inequality in the importing country i.

The term Ω_i measures the adjusted real income of importer *i* relative to the rest of the world. For income-elastic or luxury goods ($\beta_j^n > 0$), higher adjusted real income means that the country sources a higher share of good *n* from country *j*. For income-inelastic goods or necessities ($\beta_j^n < 0$), higher adjusted real income means that the country sources a lower share of good *n* from country *j*. What is new in this AIDS-gravity equation is that the income elasticities *differ by the selling country*. The richer is importer *i* (higher $\bar{x}_i$) or the more unequal it is (higher IN), the larger its expenditure share on *countries* for which it has an income elasticity greater than unity for that good ($\beta_j^n > 0$), and conversely the smaller its expenditure share on countries for which it has an income elasticity less than unity for that good ($\beta_j^n < 0$).

For trade costs, we make the standard assumption in the trade literature that they depend on distance between the countries:

$$\ln \tau_{ij}^n = \rho^n \ln d_{ij} + u_{ij}^n, \tag{9}$$

where u_{ij}^n is an error term. Substituting this into (5) and (7) we obtain,

$$\frac{X_{ij}^n}{Y_i} = A_{ij}^n + \frac{Y_j^n}{Y_W} - (\gamma^n \rho^n) D_{ij} + \beta_j^n \Omega_i + \varepsilon_{ij}^n \tag{10}$$

where D_{ij} measures the bilateral trade costs between exporter *j* and importer *i* in sector *n* and is obtained in the same manner as (7) but replacing τ with *d*. Likewise, the error term ε_{ij}^n is obtained from u_{ij}^n in (9).

The final step is to indicate how the terms $\overline{\alpha}_i^n$ and A_{ij}^n in the upper-level and lower-level

AIDS equations (3) and (10) are determined. We assume that the coefficients $\overline{\alpha}_i^n = \sum_j \alpha_{ij}^n$ are obtained from

$$\alpha_{ij}^n = \alpha_j(\alpha^n + \varepsilon_i^n), \tag{11}$$

where ε_i^n is an error term. With the assumption that $\sum_j \alpha_j = 1$, we obtain from (3) the upper-level equation:

$$S_i^n = \alpha^n + \bar{\beta}^n y_i + \varepsilon_i^n \ . \tag{12}$$

This upper-level equation slightly simplifies (3), and again, it captures how the share of spending on product *n* in each country *i* depends on its real income.

Using (11) and (12) combined with (6), we can solve for $A_{ij}^n = \alpha_j(S_i^n - S_W^n - \bar{\beta}^n\Omega_i)$. Substituting this into (10), we obtain our lower-level estimating equation,

$$\frac{X_{ij}^n}{Y_i} = \frac{Y_j^n}{Y_W} + \alpha_j(S_i^n - S_W^n) - (\gamma^n\rho^n)D_{ij} + (\beta_j^n - \alpha_j\bar{\beta}^n)\Omega_i + \varepsilon_{ij}^n \ . \tag{13}$$

Where X_{ij}^n is the value of exports from exporter j to importer i in sector n, Y_i is the total income of importer i, Y_j^n is total sales of exporter j in sector n, Y_W is world total output of all agricultural products, S_i^n is the share of sector n in the total expenditure of country i, S_W^n is the share of sector n in world expenditures, and D_{ij} is a measure of the bilateral country distance.[5] Equations (12) and (13) represent the final version of the upper-level and lower-level AIDS-gravity equations that we use for estimation. The first term on the right reflects export supply capacity and is included in place of exporter fixed effects, while we also included importer (province) fixed effects in the estimation.[6]

[5] In addition to distance D_{ij}, Fajgelbaum and Khandelwal (2016) allow for bilateral border and language barriers between exporter *j* and importer *i* in sector *n* to influence the amount of trade. Using such indicator variables is quite standard in gravity equation estimation, but we do not include them here because our focus is on a single importing country, China, comprised of 30 provinces. Within China, all provinces have the same principal language (Mandarin) and nearly all have the same lack of land borders with neighboring suppliers. So our focus will be on *distance* as the measure of trade costs.

[6] We estimate over multiple years, as explained in the next section. So most variables (except distance) vary over time, which allows the coefficients of Ω_i to be identified even with importer fixed effects.

3. Estimation

While Fajgelbaum and Khandelwal (2016) apply their method to trade between all countries in all goods, our focus here will be on agricultural products only. We focus on the 30 provinces of China, purchasing agricultural imports from 78 major exporting countries of the world. With China's rising income, rapid urbanization, expanding middle class, desire for variety, and growing food safety awareness, consumer preference on agricultural products vary substantially across provinces (Hansen et. al 2017, Gale et. al 2015). Accordingly, we use each province as an importing region. So we have *i*= 30 importers, *j*=78 countries, and *n*=58 agricultural goods over 1997-2017, and "income" Y_i is measured by total spending on all these agricultural imports by province *i* in each year. The agricultural commodities that we focus on in the paper consist of the 58 products as defined by the United States Department of Agriculture's BICO classification scheme, which divides agricultural products into three groups—*bulk*, *intermediate*, *consumer oriented*, and *othe*r agricultural related goods (hence the acronym BICO) —based on the value or level of processing[7]. We pool data over 1997-2017 in the estimation. In the Online Appendix we summarize the sources of our data.

Table 1 reports estimates of the $\bar{\beta}^n$ coefficient from the upper level of aggregation in equation (12). At the upper level of aggregation, the income elasticities are,

$$\frac{d\ln X_i^n}{d\ln Y_i} = \frac{d\ln(S_i^n Y_i\ )}{d\ln Y_i} = 1 + \frac{d\ln S_i^n}{d\ln Y_i} = 1 + \frac{dS_i^n}{d\ln Y_i}\frac{1}{S_{ij}^n} = \ 1 + \bar{\beta}^n/S_i^n, \qquad (14)$$

where S_i^n is the share of commodity *n* in the imports of province *i* from all sources. When $\bar{\beta}^n > (<) 0$, then the income elasticity for that product is greater (less) than unity. Products with an income elasticity greater (less) than unity are traditionally called luxuries (necessities),

[7] Robust estimation of firm/industry/sector-level gravity equations using export (import) data is now common in the agricultural economics literature, some recent applications including: Reimer and Li (2010) (crop trade); Jayasinghe, Beghin, and Moschini (2010) (U.S. corn seed exports); Cardamone (2011) (fruit exports); Chevassus-Lozza and Latouche (2012) (French firms' agri-food exports); Xu (2015) (agricultural trade); and Dal Bianco et al. (2016) (wine exports).

indicating that the share of expenditure on these products rises (falls) as income grows.

The upper-level elasticities in Table 1 are all between +0.03 and -0.03, so provided that a given product has an import share of at least 3% in a province, then its income elasticity in that province lies between 2 (for $\bar{\beta}^n = 0.03$) and zero (for $\bar{\beta}^n = -0.03$); but if the import share is greater than 3% in (14), then the upper-level income elasticity is correspondingly closer to unity. To give just one example, the commodity with the highest value of $\bar{\beta}^n = 0.03$ in Table 1 is soybeans, and the share of provincial imports devoted to soybeans in 2017 ranges from a high of 82% in Shaanxi to a low of 1% in Beijing (except for six provinces that do not import soybeans at all). Based on the upper-level estimates, therefore, the income elasticity of soybeans across provinces ranges from 1+(0.03/0.82) = 1.037 to 1+(0.03/0.01) = 4.

Table 2 reports estimates of the lower-level, product-exporter specific β_j^n estimates for the top 19 countries and 14 products from equation (13). Consistent with Gohin and Féménia (2009) and Heerman and Sheldon (2018), who find evidence from agricultural trade against the assumptions underlying the CES-based gravity approach, our estimates also reject homothetic taste. The estimates also suggest that varying trade elasticities are a distinguishing feature of international trade data at the industry and provincial level. The new feature of our non-homothetic system is that each country exporting to China faces its own income elasticity for each product. The income elasticity from (13) is,

$$\frac{d\ln X_{ij}^n}{d\ln Y_i} = \frac{d\ln(S_{ij}^n Y_i\ )}{d\ln Y_i} = 1 + \frac{d\ln S_{ij}^n}{d\ln Y_i} = 1 + \frac{dS_{ij}^n}{d\ln Y_i}\frac{1}{S_{ij}^n} = \ 1 + \beta_j^n / S_{ij}^n\,. \qquad (15)$$

Therefore, when $\beta_j^n > (<) 0$, then the income elasticity for the products from country *j* is greater (less) than unity. We might think of exporting countries with an income elasticity greater (less) than unity as selling high (low) quality versions of that product, which are therefore treated as luxuries (necessities) by the purchasing province. All else equal, the absolute value of the income elasticity decreases as the import share grows larger, meaning that the exporting country enjoys a relatively powerful market position.

In Table 2 we list the products by the rank order of their importance in Chinese imports, with soybeans being the most important import. Surprisingly, we see that the United States has a substantial negative estimate of $\beta_j^n = -0.047$, suggesting that soybeans are a necessity in demand. Other countries (Argentina, Brazil, Uruguay and Russia) likewise have significant negative estimates, while some have significant positive estimates. What is the source of these conflicting results for the estimated β_j^n parameter?

To understand the source of these estimates, in Figure 2 we show the provincial expenditure shares on soybean imports from the United States versus the total provincial imports of all agricultural commodities. The upper-left point in Figure 2 is for Shaanxi, where fully 43% of its imports in 2017 are devoted to U.S. soybeans. Shaanxi has small overall imports and is a relatively poor province, so we can expect that its soybean imports are either used for processing into soybean oil or are used as feed for raising livestock.[8] It is apparent that these soybean imports are not used for household *consumption,* but rather, are used for agricultural *production.* A similar set of circumstances likely apply to other *bulk and intermediate* goods listed in Tables 1 and 2: the provincial imports are *inputs* into production rather than being used for household consumption.

One way to deal with this issue would be to use an input-output table to transform the provincial imports of bulk and intermediate inputs into outputs of final food products into each

[8] Nearly all the soybeans imported by China are used to produce either high-protein meals consumed by Chinese livestock or edible oil consumed by the Chinese people. According to the China Ministry of Agriculture and Rural Affairs (2018), soybean processing capacity expanded from 20 to 160 million metric tons over 2001-2016. Shaanxi grows soybeans and processes them for edible oil, and likely added capacity during this period. China's domestically produced soybeans are used mainly to produce foods such as tofu, soy milk, soy sauce, and nutritional supplements (Gale, Valdes, and Ash, 2019).

province where they are ultimately sold. We do not have an input-output table at this very fine level of aggregation, however. A much simpler solution to this issue is to use the *upper-level* elasticities shown in Table 1 for all *bulk and intermediate* goods, while we use the *lower-level* elasticities shown in Table 2 for all *consumer and other* goods. We will take this approach as we forecast Chinese demand for agriculture goods, in the next section.

4. Forecasting Chinese Import Demand for Agricultural Products

Using the estimated AIDS-gravity system, we now forecast Chinese import demand for agricultural products. To achieve that goal, we go back to equation (1) of our system. We hold prices fixed so that our forecast purely reflects Chinese import demand. We consider three different scenarios for projecting Chinese import demand for agricultural products over one year. In the first scenario, we will assume that the growth in spending on all agricultural imports and the change in income inequality by province are the same as the *annual average* of their change over 2007–2017. That is, we just calculate the change in nominal and real spending over each future year as the annual average real change over the decade before:

$$\Delta \ln Y_i = \Delta y_i = (y_{i2017} - y_{i2007})/10. \tag{16}$$

This growth in real income – adjusted for the past average changes in income inequality – is multiplied by the non-homothetic coefficients β_j^n in (10) to obtain the change in the share of import purchases coming from each source country. The second and third scenarios are that import growth in China from 2017 is only one-half of the annual average during 2007-2017, or that imports do not grow at all from 2017.

4.1 Targets for Chinese Imports from the United States

In addition to the differing scenarios concerning growth of import demand, we also suppose that China faces a target on the minimum imports of agricultural goods that it purchases from the United States, which we denote by country 1. This constraint is written as:

$$\sum_{n=1}^{N}\sum_{i} \; p_{i1}^{n}q_{i1}^{n} \geq Y_1. \tag{17}$$

We will assume that China desires to achieve this constraint at a minimum loss of utility. That is, we will assume that China adopts the policy to maximize the utility of an aggregate consumer who faces the constraint in (17) along with a budget constraint over all agricultural goods, written as $\sum_{n=1}^{N}\sum_{j}\sum_{i} \; p_{ij}^{n}q_{ij}^{n} \leq Y$, where Y is China's *total* import purchases of agricultural goods which is held fixed.

We denote the quantity of agricultural good n that country j sends to province i in China by q_{ij}^{n}, and the vector of all purchases of good n across provinces and supplying countries by $\mathbf{q}^{n}$. Then the Lagrangian to maximize utility subject to the constraints is,

$$L = U(\mathbf{q^1},...,\mathbf{q^N}) + \lambda(Y - \sum_{n=1}^{N}\sum_{j}\sum_{i} \; p_{ij}^{n}q_{ij}^{n}) + \mu(\sum_{n=1}^{N}\sum_{i} \; p_{i1}^{n}q_{i1}^{n} - Y_1). \tag{18}$$

The marginal utility of income is $\lambda > 0.$ In addition, the Lagrange multiplier μ can be interpreted as $\partial L / \partial Y_1 = -\mu < 0,$ where this sign is established provided that Y_1 exceeds the amount of imports from the United States that China would normally choose to purchase, so that any increase in that target *lowers* welfare. It follows that $\mu > 0,$ and we further assume that $\mu < \lambda.$

The first-order conditions for problem (18) are:

$$\frac{\partial U}{\partial q_{ij}^{n}} = \lambda p_{ij}^{n}, \qquad \text{for } j \neq 1 \tag{19}$$

$$\frac{\partial U}{\partial q_{i1}^{n}} = (\lambda - \mu) p_{i1}^{n} = \lambda\left(1 - \tfrac{\mu}{\lambda}\right) p_{i1}^{n} \equiv \lambda \delta p_{i1}^{n}, \quad \text{for } j = 1 \tag{20}$$

where $\delta \equiv [1 - (\mu / \lambda)] < 1.$ It follows that the optimal policy for China to achieve the import target is to act "as if" there is an *ad valorem* subsidy on U.S. prices, lowering them by $\delta < 1$. Importantly, this "effective" subsidy is the *same* across all agricultural imports.

We stress that this policy maximizes utility in China subject to the Phase One target, and therefore minimizes the deadweight loss of achieving this target, where that deadweight less is summed across all agricultural goods. This objective gives the *uniform* import subsidy as the surprisingly solution that holds regardless of the form of the utility function (which can be nonhomothetic). Of course, this optimal policy may very well differ from the actual steps that China has taken to increase its agricultural import from the United States. We do not explore those actual steps, but instead, we calculate how the optimal solution will impact the product-by-product exports to China from the United States and other countries.

4.2 Substitution and Income Effects

In order to calculate the impact of this effective subsidy on China's imports from various countries, we use the AIDS demand equations in (1). Changing our notation from (14), we now let ΔS_{ij}^n denote the change in the share of China's imports from each country that it purchases due to the effective subsidy. Noting that the log of U.S. effective prices falls by $\ln \delta < 1$ from (20), then from (1) we obtain:

$$\Delta S_{ij}^n = \frac{1}{N}\gamma^n \ln \delta + \beta_j^n \Delta y_i \quad \text{for } j \neq 1, \tag{21}$$

$$\Delta S_{i1}^n = -(1 - \frac{1}{N})\gamma^n \ln \delta + \beta_1^n \Delta y_i \quad \text{for } j = 1. \tag{22}$$

where we have made use of the normalizations just below (2) that $\gamma_{jj'}^{nn'} = -(1 - \frac{1}{N})\gamma^n$ for $n = n'$ and $j = j'$; $\gamma_{jj'}^{nn'} = \gamma^n / N$ for $n = n'$ and $j \neq j'$; and $\gamma_{jj'}^{nn'} = 0$ for $n \neq n'$.

The first terms appearing in (21) and (22) are a conventional substitution effect, which always increases China's imports from the United States and decreases China's imports from other countries. We note that the magnitude of the substitution effect depends on the number of countries competing with the United States. We have referred to that number as *N* in the above equations, but as noted in section 2, it actually measures the numbers of source countries for each product and province and should therefore be properly written as N_i^n. The *larger* is N_i^n, then the greater is the substitution effect $-\left(1-\frac{1}{N_i^n}\right)\gamma^n\, ln\,\delta > 0$ towards U.S. exports, but the smaller (in absolute magnitude) is the substitution effect $\frac{1}{N_i^n}\gamma^n \ln\delta < 0$ away from other countries.

The second terms appearing in (21) and (22) are the income effects associated with an effective subsidy on imports from the US. To solve for the change in real income, we use the log of the homothetic price index $\ln a_i = \sum_n \sum_j \alpha_{ij}^n \ln p_{ij}^n + \frac{1}{2}\sum_n \sum_j \sum_{n'}\sum_{j'} \gamma_{jj'}^{nn'} \ln p_{ij}^n \ln p_{ij'}^{n'}$ appearing in (2). Notice that the change in this log index with respect to a change in a US import price is:

$$\frac{d\ln a_i}{d\ln p_{i1}^n} = \alpha_{i1}^n + \sum_{n'}\sum_{j'} \gamma_{1j'}^{nn'} \ln p_{ij'}^{n'} \approx S_{i1}^n,$$

which is similar to the share S_{i1}^n from (1) except that it omits the nonhomothetic portion in (1). In empirical AIDS applications, it is common to use S_{i1}^n to approximate the above expression, as we shall do. It follows from (2) that the total change in real income from all US import prices dropping by $\ln\delta < 1$ is:

$$\Delta y_i = -\Delta \ln a_i \approx -\sum_n S_{i1}^n \ln\delta\ . \tag{23}$$

In (23), we sum the U.S. shares over all products *n* sold to each province *i* in China, reflecting the common subsidy across all these imports. In practice, however, we might expect that the state authorities in China would direct firms and consumers to increase their imports without actually lowering the price. In that case, the income effect will be much less than shown in (23). To prevent the income effect from being too large and dominating our calculations, we will compute it using only the US share *coming from each product n being analyzed*, namely:

$$\Delta y_i \approx -S_{i1}^n \ln\delta\ . \tag{24}$$

Substituting (24) into (21), we obtain the change in the provincial share of good *n* imported from countries other than the United States,

$$\Delta S_{ij}^{n} = \left(\frac{\gamma^{n}}{N_{i}^{n}} - S_{i1}^{n}\beta_{j}^{n}\right)\ln\delta \quad \text{for } j \neq 1. \tag{25}$$

For imported products from country *j* that have income elasticities less than or equal to unity, so that $\beta_j^n \leq 0$, the effective subsidy on U.S. product combined with the effective rise in real income will lead to a reduced share of purchases from that country. On the other hand, if purchases from country *j* are sufficiently luxuries ($\beta_j^n > 0$) so that $S_{i1}^n\beta_j^n > \gamma^n / N_i^n$, then there would be an *increased* import share because purchases from country *j* are complementary with those from the United States. We will find that this complementary relationship holds for some countries exporting soybeans to China, but not for any other imported products.[9]

We can also substitute (24) into (22), to obtain:

$$\Delta S_{ij}^{n} = -\left[\left(1 - \frac{1}{N_i^n}\right)\gamma^{n} + S_{i1}^{n}\beta_{1}^{n}\right]\ln\delta \quad \text{for } j = 1. \tag{26}$$

Recalling again that $\ln\delta < 0$, then with $S_{i1}^n\beta_j^n > -\left(1 - \frac{1}{N_i^n}\right)\gamma^n$ there will be an increased share of purchases from the United States. This condition rules out a backward-bending demand curve and is always satisfied in our data. Having a luxury good ($\beta_1^n > 0$) means that the positive income effect adds to the substitution effect in raising imports from the United States.

The effective subsidies therefore create both substitution effects – which occur *within* the same products that the United States is exporting to China – and income effects, which can possibly create complementarity between U.S. exports and those of other countries. There is a final effect which we must consider, and that is the substitution effect *across* products. That was ruled out in the initial estimation of our parameters because we assumed that $\gamma_{jj'}^{nn'} = 0$ for $n \neq n'$. But cross-

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[9] If demand were homothetic then $\beta_j^n = 0$ and the second term on the right of (25) – capturing the extra income effect from nonhomothetic demand – would vanish, and likewise for the final term in brackets in (26). In that case the complementary relationship between soybean imports from the United States and other countries would not arise; see the end of section 5.1 for further discussion. On the other hand, if we used the stronger income effects like in (23) then other imported products besides soybeans might also show a complementary relationship between imports from the US and other countries.

product substitution can still enter into our results, for a subtle reason we mentioned in section 2. Specifically, as the effective subsidy increases on U.S. products, it is entirely possible that the drop in the share of China's purchases from other countries – ΔS_{ij}^{n} in (25) – *exceeds* the initial purchases from that country, so that the share should be zero. That involves an adjustment to all the parameters of the AIDS equation (1), as discussed just below that equation, so that the sum of shares over all products and source countries for each province continues to be unity. We have implemented that adjustment by first replacing the (hypothetical) negative share with zero, in which case the sum of shares exceeds unity. Then we *subtract* the same, small amount needed from all the (positive) shares in that province so that the sum of shares is again unity. This procedure, which can be justified theoretically,[10] leads to a slight reduction in import shares of all products and source countries in a province, even for products that the United States *does not* export. In other words, there is a cross-product substitution created by the effective subsidies.

To summarize, equations (25) and (26) will be used to mimic the effect of an import subsidy on U.S. product, where we will change the size of the effective subsidy in order to meet the Phase One targets for 2020 and 2021. We have held fixed China's *total* import purchases of agricultural imports, denoted by *Y*. It follows that the increase in China's agricultural imports from the United States will equal the reduction in total imports from other countries. If our estimation of the AIDS-gravity equation had included additional goods beyond agricultural imports (such as home-produced or nonagricultural goods), then total agricultural imports *Y* could have changed endogenously in response to the effective subsidy, thereby allowing imports from other countries to fall by more or less than the rise in imports from the United States. But results of that type are beyond the scope of this paper.

[10] Feenstra (2010) shows how the parameters of an AIDS expenditure function must be adjusted when there are new or disappearing goods, and this implies an adjustment to the shares so that they sum to unity. An empirical application to a translog expenditure functions is in Feenstra and Weinstein (2017).

4.3 Calibration

As explained in the previous section, for *bulk and intermediate* goods, we replace the lower-level parameters β_j^n with their upper-level values $\bar{\beta}^n$ for each product. Also appearing in (25) and (26) are S_{i1}^n and γ^n. For the former, we use the share of imports from the United States, S_{i1}^n, in each province and product in 2017. The parameter γ^n was not well-estimated from the coefficient of the distance term in the AIDS-gravity equation (13). The reason for this is that the distance term D_{ij} measures the bilateral trade costs between exporter *j* and importer *i* in sector *n* and is obtained in the same manner as (7) but replacing τ with *d.* As can be seen from (7), the distance term actually measures the *cross-provincial differences* in the distance to trading partners. While we attempted to capture such cross-provincial differences by using their distances to the nearest Chinese ports, this method was not successful in obtaining reliable estimates of γ^n.

Accordingly, we calibrate this parameter using estimates from Fajgelbaum and Khandelwal (2016). They report an estimate on distance in their AIDS-gravity equation—estimated over agricultural products—of 0.0011 and varying between 0.0013 and 0.0009. We shall use an average value of 0.0010 to calibrate that distance parameter, which equals the combined parameters $\gamma^n\rho^n$ in (13). Following Fajgelbaum and Khandelwal again, we use a calibrated value of $\rho^n = 0.177,$ so that we obtain $\gamma^n = 0.0010/0.177 = 0.00565$. This value for γ^n is used in all our calculations.

5. Forecast Results

5.1 Imports from the United States

In Table 3 we report China's demand for agricultural imports from the United States under our three growth scenarios: when the annual change in real spending on all agricultural imports from 2017 is equal to its average annual growth over 2007-2017, or one-half that amount, or zero growth from 2017. In the first case, China's import demand increases by roughly 10% per year. Still, we see from Table 3 that China's imports from the United States fall short of the Phase One targets in both

2020 and 2021: import demand from the United States is $33.6 billion in 2020 as compared with the target of $36.6 billion, and import demand is $37.5 billion in 2021 as compared with the target of $43.6 billion. Reaching both of these targets would require an effective subsidy from China of 12% in 2020 and 23% in 2021. These subsidies would lead to increases in U.S. imports of $2.9 and $6.1 billion in 2020 and 2021, respectively, or percentage increases of 8.6% and 16.3%.

In the remaining rows of Table 3, we summarize the results for a growth rate of one-half of that which occurred during 2007-2017 and for zero import growth from 2017. In the former case, the needed effective subsidies on U.S. imports to reach the Phase One targets in 2020 and 2021 are 28% and 41%, respectively, and in the latter case with zero-growth, the needed subsidies are 42% and 59%, respectively. These subsidy rates on the United States are high and show that it would be challenging to achieve the increase in imports needed to fulfill the Phase One targets through state command.

In Table 4, we report the increase in imports from the United States that would occur in specific agricultural products, focusing on those products with U.S. exports to China in 2017 greater than $500 million.[11] The top selling U.S. export is soybeans, followed by forest products, cotton, coarse grains, hides & skins, fish products, pork, and dairy products. We show the impact of the effective subsidies on the United States needed to reach the Phase One targets in 2020 and 2021. For brevity, in each of those years, we report only the relevant subsidy that reaches the Phase One target under the zero-growth scenario, where China's import demand for each agricultural product is the same as in 2017. With the effective subsidy of 42% in 2020, forest products have the greatest increase in exports to China ($359 million, or 17.3%), while soybean exports grow by $289 million (only 2.1%, from a very high base of $13.9 billion). The effective subsidy of 59% in 2021 leads to even higher exports of $559 million (26.9%) for forest products and $530 million (3.8%) for

[11] The change in U.S. exports to China for the complete set of products is reported in Online Appendix Table A2.

soybeans.[12]

We have also calculated the aggregate results shown in Table 3 for the case of homothetic demand, in which case $\beta_j^n = 0$ and the second term on the right of (25) – capturing the extra income effect from non-homothetic demand – would vanish, and likewise for the final term in brackets in (26).[13] Interestingly, we find that the comparison with the nonhomothetic case depends on which growth scenario we consider. Under our first growth scenarios, when real agricultural imports from 2017 onwards grow as during 2007-2017, then we find that the effective import subsidy of 12% would lead to greater imports than shown in Table 3 for both 2020 and 2021, so that the *sum* of imports from the U.S. over these two years would approximately meet the cumulative Phase One target over those two years. However, under the zero growth scenario from 2017, we find that the results for the effective subsidies of 42% and 59% as shown in Table 3 are not too different with homothetic demand (U.S. imports are only very slightly higher), so the increased subsidy in 2021 is needed to meet the Phase One targets.[14] Of course, the results for specific import produce can be expected to be quite different depending on whether demand is homothetic or non-homothetic.[15]

5.2 Imports from Other Countries

By assumption in our framework, China's imports from other countries would fall by the *same amount* in total as the increase in imports from the United States. However, we are especially interested in how that diversion of imports is spread across other countries. In Table 5, we report the decrease in imports from the rest of the world (ROW) in 2020 and 2021, and for individual supplying

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[12] Forest products such as hardwood lumber are not considered to be agricultural goods in the Phase One targets for the United States but rather manufactured goods. Because we have not analyzed the Phase One manufacturing targets in this study, we have included forest products within agriculture.

[13] These results are reported in Table A3 of the Online Appendix, and the complete files for computing the homothetic case (from which the results for other countries and specific products can be obtained) are included in the dataset for this paper, Feenstra and Chang (2021).

[14] The results for the scenario of one-half the previous average annual growth are in-between these two other scenarios: i.e. the subsidy of 28% leads to 2020 imports that exceed the target, but 2021 imports that are too low; but the subsidy does not need to rise to 41% to meet the 2021 target.

[15] See note 9.

countries.[16] Once again, we report only the impact of the subsidies under the zero-growth scenario. For example, in the first row of Table 5, we report that the ROW would sell $12.5 billion less to China under a 42% subsidy in 2020 and $19.5 billion less to China under a 59% subsidy in 2021. These dollar amounts equal the dollar increase in China's imports from the United States under zero growth, but the *percentage* decrease for the ROW is smaller because China's agricultural imports from the United States are only about one-quarter as large as for the ROW. The percentage reduction in China's imports from the ROW to achieve the Phase One targets are 11.8% and 18.4% (Table 5, first row).

For individual supplying countries, the percentage reduction in China's purchase of their imports can be higher or lower than that for the ROW, while the *average* over all non-U.S. supplying countries will equal the percentage reduction for ROW in total. In Table 5, we rank the individual countries by their exports to China in 2017. The top supplier after the United States is Brazil. It suffers a loss in exports to China of 2.5% and 4.0% in 2020 and 2021, respectively, which is much less that for the ROW overall (which is a decline of 11.8% and 18.4%). The modest impact on Brazil occurs because it is a principal supplier of soybeans to China, and in that commodity, there is weaker substitution (and sometimes a complementary relationship) between imports from the United States and those from some other countries, as we will explain below.

The next largest exporter to China is Australia, and it suffers the largest dollar drop in exports to China of all countries, with a percentage drop nearly equal to the ROW overall. Canada is the only country among the top-five exporters to China that has a percentage drop in exports that *exceeds* the ROW overall. These two countries – Australia and Canada – experience trade diversion of close to $1 billion in 2020 and exceeding $1 billion in 2021. Following those two countries, the next largest

[16] The change in exports to China for the top exporters besides the United States and for the complete set of products are reported in Online Appendix Tables A4-A17.

drop in exports to China occurs for Brazil, Malaysia, Indonesia, Thailand, and Vietnam, with trade diversion of close to $0.5 billion in 2020, and between $0.75 and $1.0 billion in 2021. Next, a group of countries—including Argentina, France, Germany, the Netherlands, and New Zealand — experience trade diversion of between $0.33 and $0.5 billion in 2021 and $0.5 to $0.75 in 2021. Spain and South Korea have declines in exports that are close to those lower amounts, followed by Chile and Japan. It is evident that the ranking of countries by their exports to China (Brazil is at the top after the United States) and by their *loss* in exports (Australia and Canada are highest) are not the same, and we can turn to individual products to understand this difference.

5.3 Results for Specific Products

To understand in more detail the sources of these export declines by country, we report results for specific agricultural products. We begin with the largest agricultural export from Australia to China: coarse grains (except corn). In Table 6, we report the change in China's imports from the United States, the ROW in total, and each country individually, provided that it has sales to China over $100 million.[17] We report only the impact of the subsidies under the zero-growth scenario. China's imports from the United States grow by about $120 million in 2020 and $230 million in 2021 under the effective subsidies of 42% and 59% needed to achieve the Phase One targets. The reductions in imports from the ROW are much larger: $170 million in 2020 and $240 billion in 2021. So, we see that for this commodity, the import reductions from the ROW *exceed* the U.S. gain. This difference between the U.S. export gain and ROW export loss occurs because of the income effects, which are the second terms included in (25) and (26).[18]

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[17] The complete list of countries exporting more than $50,000 worth of coarse grains to China in 2017 is reported in Appendix Table A7. There are 15 of these countries besides the United States.

[18] It is readily shown from (25) and (26) that the substitution effects (the first terms included in each equation), when summed over the $N_i^n - 1$ countries other than the United States in (25) and added to the U.S. effect in (26), equal zero on a crop-by-crop basis.

Coarse grains are included as "bulk" in the BICO classification, so we have used the upper-level parameter value $\bar{\beta}^n = -0.009$ in Table 1, so coarse grains are a necessity overall, with income elasticity less than unity. Such necessities have a *negative* income effect in (26), in which case both the substitution and income effects lead to reduced imports from countries other than the United States, which explains why China's imports from the ROW fall by more than the rise in imports from the United States. As a result, China's total imports for this product fall.

Different results are found for soybeans, which is a major export from both the United States and Brazil.[19] Since this product is also listed as "bulk" under the BICO classification, we have again used the upper-level parameter value $\bar{\beta}^n = 0.030$ from Table 1, so that soybeans are a luxury good with income elasticity greater than unity. In Table 7, the effective subsidy on the United States of 42% in 2020 and 59% in 2021 increases U.S. soybean exports to China in those years by roughly $300 million and $500 million, respectively. One the other hand, declines of nearly $100 million in each year are experienced by Brazil and Argentina, with a very slight decline by Uruguay. The remaining countries shown in Table 7 – including Canada, Russia, Ukraine and small suppliers – all have *increases* in their exports to China. Indeed, the *total* reductions in China's ROW imports are modest, at about $150 million in 2020 and only $37 million in 2021, much less than the rise in imports from the United States. So, for soybeans, China's total imports *rise* with the effective subsidy.

Soybeans illustrate the potential for a complementary relationship between China's imports from the United States, which occur because we are treating soybeans as a luxury good and the expenditure share on the United States is high in many provinces. That combination of parameters creates a strong positive income effect, $S_{i1}^n \bar{\beta}^n$, as appears in (25) and (26), which is multiplied by

[19] The United States and Brazil together supply over 80% of global soybean exports, with Argentina being the third largest exporter. China was the destination for 61% of U.S. soybean exports and 77% of Brazil's soybean exports in 2017.

$-\ln \delta > 0$ to create an especially strong income effect in 2021. Soybeans is the only product for which we find a complementary relationship between China's imports from the United States and from other countries. The fact that China's soybean imports from the United States and from the ROW are rising means that imports of other products must be falling, because we have held its total imports fixed at Y_1 in our theoretical model and at their 2017 level in our zero-growth scenario. We have already seen that China reduces its imports of coarse grains from the ROW by more than the increase in its imports from the United States due to the negative income effect, and the same pattern will arise for other necessities.[20] But it is worth considering if other features are at work in our AIDS model that can contribute to reduced ROW imports.

To answer this question, let us consider China's imports from Canada. As was noted in Table 5, Canada has the greatest percentage loss among the top-five countries exporting to China. Canada's loss in exports of coarse grains is about half as large as for Australia (Table 6), and as we have just seen (Table 7), Canada's soybean exports to China actually increase. So where does the large loss in Canada's exports occur? Canada's top agricultural export to China is rapeseed, and that is also the product where Canada experiences the greatest drop in exports.[21] We report China's imports of rapeseed in Table 8. China buys rapeseed from only four countries, but nearly all of these imports come from Canada. In 2017, Canada's rapeseed exports to China totaled \$2 billion. Those imports fall by about \$250 million in 2020 and \$340 million in 2021 due to the effective subsidy on U.S. products.

This result is not surprising since rapeseed and soybeans are substitutes, and the cross-product substitution that we referred to in the previous section is helping to drive the decline in

[20] In Online Appendix Tables A6-A8, we report the change in China's imports for cotton, which is a necessity from Table 1, and pork and beef, which are necessities in their exports from some countries and luxuries from others. The fall China's ROW imports for each of these products exceed the rise in US imports.

[21] See Online Appendix Table A14 for the change in Canada's exports of specific products to China.

China's rapeseed imports from Canada. Specifically, each province importing rapeseed will experience a decline in the price of other imports from the United States with the effective subsidy. Due to substitution (and negative income effects if they occur), the province's imports of those products from the ROW will fall. But in many cases, the expenditure share S_{ij}^{n} on imports from a given country *j* can fall to zero, and as the subsidy on U.S. product is raised, it cannot fall further. The import share on the United States, S_{i1}^{n}, continues to rise with the subsidy, but if the share of competing countries cannot fall past zero, then all shares in each province must be adjusted so that their sum in each province still equals unity. That adjustment is done by subtracting the same, small value from all (positive) shares in a province so that they sum to unity.

This procedure creates a *cross-product* substitution in our analysis, as illustrated by the reduction in Canada's rapeseed exports to China. To express this substitution pattern in less technical language, we can think of the subsidy on soybeans – used, for example, to create soybean oil for consumers – as implemented by command or by fiscal incentives to processing factories in China. Increased soybean imports from the United States would lower the price of soybean oil for consumers, leading to increased demand. That consumer decision would incorporate a positive income effect on soybean purchases. In addition, there can be cross-product substitution away from other products—in particular, away from canola oil that is processed from rapeseed. In this way, the effective subsidy on U.S. soybean imports provided to processing plants in China can result in less rapeseed imports from Canada, as we have found.

6. Conclusions

The administration of President Trump engaged in numerous trade policy actions with China. In December 2019, the United States and China reached a Phase One agreement, under which China committed to purchase more imports from the United States in 2020 and 2021. While the coronavirus pandemic in 2019-21 and the election of President Biden may render this agreement moot or at least delay its implementation, it is still worth asking whether it could have been achieved.

We have shown that the *most efficient* way for China to import more from the United States is to mimic the effect of an import subsidy on U.S. product. The magnitude of these "effective" subsidies on the United States depend on the assumptions of how much China's imports would have grown since 2017, and we have considered three scenarios. In the first, if China's agricultural imports grew at the same annual rate from 2017 as during 2007-2017, then we find that the effective subsidies would need to be 12% and 23% to achieve the targets in 2020 and 2021, respectively. But if import growth was only one-half of that amount, then the subsidies would need to be 28% and 41%; while if there was zero growth from 2017, then the subsidies would need to be 42% and 59%. In fact, China's agricultural imports from the United States *fell* from 2017 to 2019, so we focus on the zero-growth scenario in most of our calculations.

These subsidy rates on imports from the United States are admittedly very high. We are agnostic on whether such an import subsidy will actually be put into place, or whether it would be achieved via state command. In either case, it can be expected that the increased imports from the United States would result in trade diversion away from the ROW. In our analysis, we have assumed that the increased imports from the United States and decreased imports from the ROW are equal when calculated over *all agricultural imports.* But that does not mean that they are equal on product-by-product basis. On the contrary, we have shown that both substitution and income effects influence importing decisions in China under the effective subsidies on U.S. product. The income effects depend on whether goods are inferior or luxuries: that is, whether China's income elasticities for imports from particular source countries are less than or greater than unity.

In our results, we find some products where the increase in China's imports from the United States is *less than* the decrease in imports from the ROW, such that total imports fall. That case occurs for necessity goods, in particular (with income elasticities less than unity for some countries). We have also found products where the decrease in imports from the ROW is *less than the* increase in China's imports from the United States, such that total imports rise. That case occurs for soybean imports, which are a luxury good, and in this case the income effect is so strong that China's imports from some countries are complementary with those from the United States, and therefore rise rather than fall with the Phase One targets. Finally, we have also found products – rapeseed, in particular – where China's imports from ROW countries (principally Canada) fall *despite* the fact that the United States does not export this product to China, so there is no effective subsidy on U.S. product. This case illustrates the potential for *cross-product* substitution in our AIDS-gravity equation. These results for rapeseed and all other products show a rich pattern of trade diversion across source countries due to the Phase One targets.

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Figure 1: China Agricultural Imports ($ bill) from USA and ROW, 1997-2019

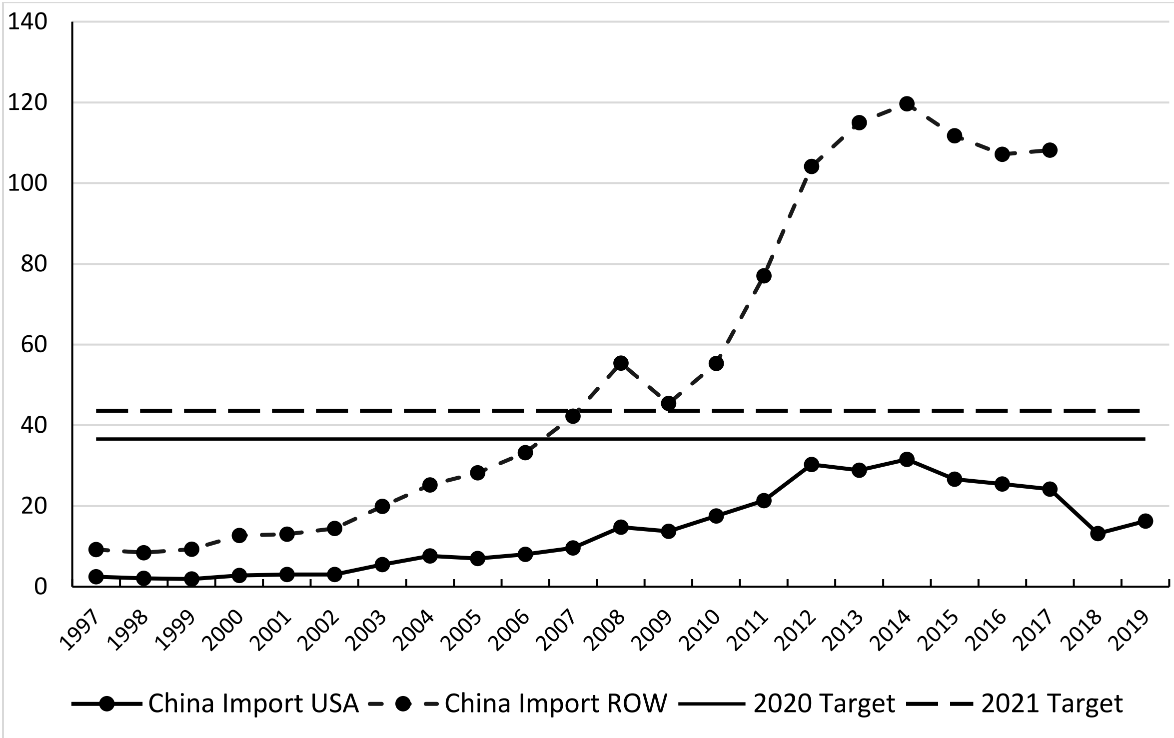
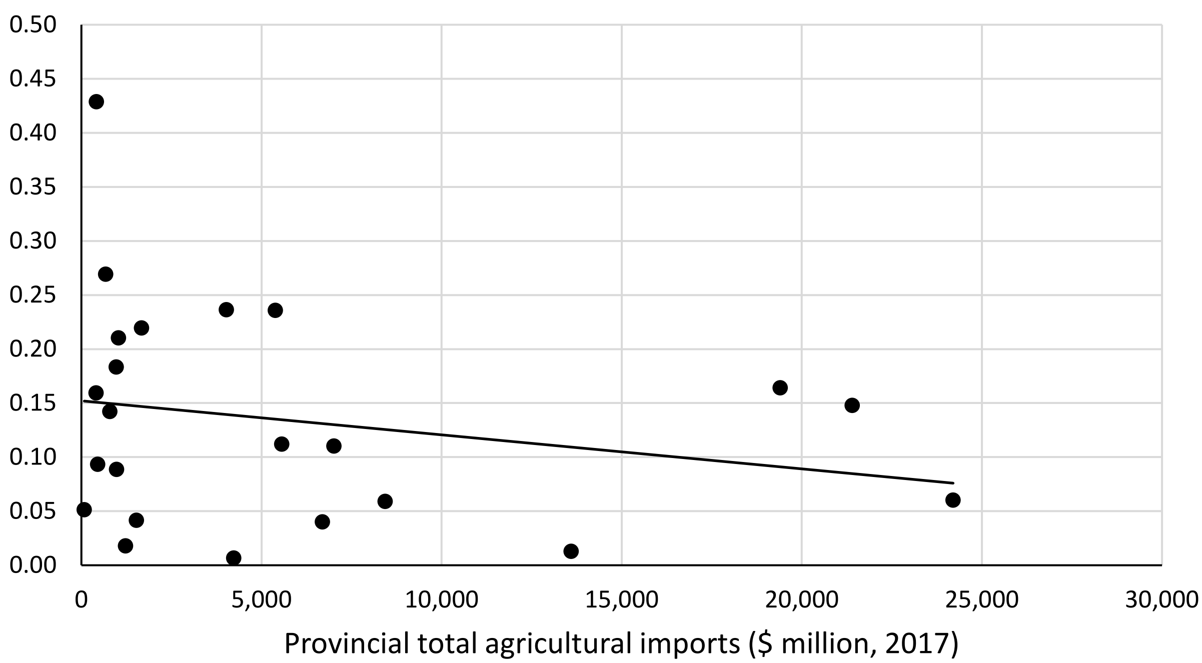


Figure 2: China's Import Share of Soybeans from the USA, 2017 by Province



Sources: China Customs Trade Data, and USDA for 2018 and 2019.

Table 1: Estimates of $\bar{\beta}^n$ Coefficient from Equation (12)

BICO Category	Agricultural Products	$\bar{\beta}^n$ Estimate	Std. Error
Bulk	Wheat	-0.011**	(0.004)
Bulk	Corn	0.001	(0.005)
Bulk	Coarse Grains (except corn)	-0.009*	(0.004)
Bulk	Rice	-0.003	(0.004)
Bulk	Soybeans	0.030**	(0.004)
Bulk	Rapeseed	-0.012*	(0.005)
Bulk	Oilseeds NESOI	0.003	(0.003)
Bulk	Cotton	-0.012**	(0.003)
Bulk	Peanuts	0.001	(0.006)
Bulk	Pulses	0.005	(0.004)
Bulk	Coffee, Unroasted	0.001	(0.005)
Bulk	Cocoa Beans	-0.001	(0.008)
Bulk	Tobacco	0.003	(0.004)
Bulk	Rubber & Allied Gums	-0.025**	(0.003)
Bulk	Other Bulk Commodities	-0.005^{+}	(0.003)
Intermediate	Soybean meal	-0.041**	(0.004)
Intermediate	Oilseed Meal/Cake (except soybean)	0.002	(0.004)
Intermediate	Soybean Oil	-0.014**	(0.004)
Intermediate	Palm Oil	-0.021**	(0.003)
Intermediate	Vegetable Oils NESOI	-0.006*	(0.003)
Intermediate	Distillers Grains	0.003	(0.006)
Intermediate	Hay	0.003	(0.006)
Intermediate	Feeds & Fodders NESOI	0.000	(0.003)
Intermediate	Live Animals	0.011**	(0.003)
Intermediate	Hides & Skins	-0.007*	(0.003)
Intermediate	Animal Fats	-0.000	(0.004)
Intermediate	Essential Oils	0.002	(0.003)
Intermediate	Planting Seeds	0.003	(0.003)
Intermediate	Sugars & Sweeteners	0.002	(0.003)
Intermediate	Other Intermediate Products	-0.015**	(0.003)
Consumer-ready	Beef & Beef Products	0.005	(0.004)
Consumer-ready	Pork & Pork Products	0.009*	(0.004)
Consumer-ready	Poultry Meat & Prods. (except eggs)	0.003	(0.004)
Consumer-ready	Meat Products NESOI	0.002	(0.003)
Consumer-ready	Eggs & Products	0.002	(0.004)
Consumer-ready	Dairy Products	0.009**	(0.003)

Consumer-ready	Fresh Fruit	0.003	(0.004)
Consumer-ready	Processed Fruit	0.003	(0.003)
Consumer-ready	Fresh Vegetables	0.003	(0.004)
Consumer-ready	Processed Vegetables	0.000	(0.003)
Consumer-ready	Fruit & Vegetable Juices	0.001	(0.003)
Consumer-ready	Tree Nuts	0.002	(0.004)
Consumer-ready	Chocolate & Cocoa Products	0.002	(0.003)
Consumer-ready	Snack Foods NESOI	0.003	(0.003)
Consumer-ready	Condiments & Sauces	-0.000	(0.003)
Consumer-ready	Prepared Foods	0.014**	(0.003)
Consumer-ready	Spices	0.002	(0.003)
Consumer-ready	Tea	0.001	(0.004)
Consumer-ready	Coffee, Roasted and Extracts	0.001	(0.004)
Consumer-ready	Non-Alcoholic Bev. (except juices, coffee, tea)	0.000	(0.004)
Consumer-ready	Wine & Beer	0.005	(0.003)
Consumer-ready	Dog & Cat Food	0.001	(0.006)
Consumer-ready	Nursery Prod. & Cut Flowers	0.003	(0.003)
Other	Distilled Spirits	0.003	(0.004)
Other	Ethanol	0.003	(0.004)
Other	Biodiesel & Blends > B30	0.008**	(0.003)
Other	Forest Products	-0.009**	(0.003)
Other	Fish Products	0.001	(0.003)
Observations	23,812		
R-squared	0.386		

Note: Standard errors in parentheses; ** p<0.01, * p<0.05, + p<0.10

Table 2: Product-Exporter Specific β_j^n Estimates from Equation (13)

Country	Soybeans	Forest Products	Cotton	Hides & Skins	Distillers Grains	Coarse Grains (except corn)	Fish Products	Corn	Pork & Pork Products	Biodiesel & Blends > B30	Dairy Products	Wheat	Prepared Foods	Hay
USA	-0.047**	0.013**	-0.006**	0.005**	0.005	-0.009**	-0.005*	-0.022**	-0.003	0.007**	0.000	-0.012**	0.005**	-0.006*
Brazil	-0.067**	-0.009**	0.012**	0.017**	0.001	0.001	0.035**	-0.021	0.009	-0.008*	-0.007	na	-0.001	na
Australia	0.051**	-0.002	-0.008**	-0.027**	-0.029	-0.028**	-0.001	0.001	0.002	0.001	0.004*	-0.006^+	-0.001	0.005
Thailand	0.136**	0.014**	-0.007	0.006	-0.001	-0.001	-0.002	0.008	0.001	0.001	-0.004	0.174	0.001	na
Canada	0.005	0.009**	0.004	0.003	0.001	-0.002	0.000	0.003	0.002	-0.004^+	0.000	-0.040**	0.001	0.001
Malaysia	0.023^+	0.016**	0.012**	0.018**	na	-0.016	0.006*	0.001	0.001	-0.001	0.002	0.01	0.003	0.005
Indonesia	0.010	0.019**	0.002	0.007	na	0.005	0.002	-0.011	-0.004	-0.004	0.003	na	0.000	0.002
New Zealand	0.121	0.007**	0.011	0.005^+	na	-0.015	0.006^+	na	0.002	-0.001	0.003	na	0.001	0.001
Argentina	-0.011**	-0.009**	0.003	0.014**	na	0.007	0.009^+	0.000	0.001	-0.005	-0.002	-0.053	-0.001	0.001
Russia	-0.046**	-0.097**	0.080**	0.047**	na	-0.011	0.014**	-0.005	-0.027*	-0.036**	-0.007^+	0.004	-0.011**	-0.001
Vietnam	na	-0.039**	0.008	0.008*	0.001	0.027	-0.001	0.000	0.001	0.001	-0.002	na	-0.002	0.001
France	0.025	0.001	0.004	0.000	0.000	-0.018**	0.003	0.012	0.001	-0.001	0.002	-0.007	0.001	-0.001
India	0.008	0.001	-0.001	0.004	na	0.004	0.004	-0.001	-0.001	0.000	-0.002	0.001	0.000	0.001
Netherlands	-0.008	0.000	-0.001	0.000	-0.001	-0.001	0.004	-0.024	0.002	0.001	-0.002	na	0.001	0.000
Germany	0.004	0.008**	0.000	-0.001	0.000	0.000	0.001	-0.001	0.004	0.004**	0.001	-0.003	0.001	0.000
Uruguay	-0.010*	0.000	0.001	0.003	na	0.001	0.004	na	-0.001	0.002	0.000	na	0.000	na
South Korea	-0.001	0.006**	0.001	0.001	0.001	-0.001	0.000	-0.003	0.005	-0.001	0.001	0.017	0.002	-0.001
Chile	0.018	-0.001	-0.002	0.003	na	0.043**	0.002	0.001	0.002	-0.017**	0.000	na	0.000	na
Japan	0.004	0.001	0.000	0.001	0.000	0.005	-0.002	0.002	0.001	0.015**	0.000	0.005	0.002	0.000

Note: ** Significant at the 1% level; * significant at the 5% level; $^+$ significant at the 10% level. Na = not applicable.

Table 3: Forecast of China's Import Demand from the United States

	2020	2021	Impact on U.S. imports		
	billion US$		Year	bill US$	Percent
Phase One Target	**36.6**	**43.6**			
Average 2007-17 growth from 2017	33.62	37.52			
Average 2007-17 growth, **subsidy = 12%**	**36.50**	40.15	2020	+2.88	8.6%
Average 2007-17 growth, **subsidy = 23%**	39.96	**43.63**	2021	+6.11	16.3%
0.5*Ave 2007-17 growth from 2017	28.41	30.07			
0.5*Ave 2007-17 growth, **subsidy = 28%**	**36.63**	38.28	2020	+8.22	28.9%
0.5*Ave 2007-17 growth, **subsidy = 41%**	41.67	**43.42**	2021	+13.35	44.4%
Zero growth from 2017	24.1	24.1			
Zero growth from 2017, **subsidy = 42%**	**36.62**	36.62	2020	+12.52	52.0%
Zero growth from 2017, **subsidy = 59%**	43.56	**43.56**	2021	+19.46	80.7%

Note: These results and all other tables use nonhomothetic demand, as explain in the text. Aggregate results with homothetic demand are reported in Online Appendix Table A2.

Table 4: Impact on Major U.S. Agricultural Exports, Assuming Zero Growth from 2017

Product	No Subsidy 2020 & 2021 Million US$	Subsidy=42% Difference from 2020 Million US$	Subsidy=42% Difference from 2020 Percent	Subsidy=59% Difference from 2021 Million US$	Subsidy=59% Difference from 2021 Percent
Soybeans	13,858.8	289.2	2.1%	529.7	3.8%
Forest Products	2,080.7	359.0	17.3%	558.7	26.9%
Cotton	975.3	278.3	28.5%	429.3	44.0%
Coarse Grains (ex. corn)	918.2	117.7	12.8%	228.0	24.8%
Hides & Skins	898.7	309.6	34.5%	478.7	53.3%
Fish Products	607.3	305.7	50.3%	473.8	78.0%
Pork & Pork Products	535.5	308.6	57.6%	476.7	89.0%
Dairy Products	529.9	322.4	60.8%	499.1	94.2%

Note: Only products with 2017 export sales to China exceeding $500 million are shown. Results for the complete set of products that the United States exported to China in 2017 are reported in Online Appendix Table A3.

Table 5: China's Import Demand from the Rest of the World, Zero Growth from 2017

	Country	No Subsidy 2020 & 2021 Billion US$	Subsidy=42% Difference from 2020 Billion US$	Percent	Subsidy=59% Difference from 2021 Billion US$	Percent
	ROW	105.86	-12.52	-11.8%	-19.46	-18.4%
1	Brazil	24.08	-0.59	-2.5%	-0.96	-4.0%
2	Australia	9.18	-0.99	-10.8%	-1.67	-18.1%
3	Thailand	7.65	-0.51	-6.6%	-0.90	-11.8%
4	Canada	6.38	-0.87	-13.6%	-1.34	-20.9%
5	Indonesia	5.81	-0.49	-8.5%	-0.82	-14.1%
6	New Zealand	5.34	-0.43	-8.1%	-0.75	-14.0%
7	Malaysia	4.34	-0.48	-11.2%	-0.79	-18.3%
8	Vietnam	3.73	-0.57	-15.2%	-0.92	-24.5%
9	Argentina	3.55	-0.31	-8.6%	-0.41	-11.5%
10	France	2.99	-0.42	-14.0%	-0.69	-23.1%
11	Netherlands	2.93	-0.44	-14.9%	-0.65	-22.3%
12	Chile	2.12	-0.26	-12.3%	-0.45	-21.1%
13	Germany	1.97	-0.35	-18.0%	-0.59	-29.9%
14	Uruguay	1.86	-0.20	-11.0%	-0.24	-13.0%
15	Russia	1.77	-0.15	-8.3%	-0.21	-12.0%
16	Spain	1.46	-0.32	-22.0%	-0.53	-36.5%
17	Denmark	1.44	-0.22	-15.2%	-0.36	-24.7%
18	Ukraine	1.13	-0.28	-25.1%	-0.43	-38.5%
19	India	1.09	-0.30	-27.5%	-0.46	-42.4%
20	South Africa	0.97	-0.18	-18.4%	-0.27	-27.7%
21	South Korea	0.96	-0.32	-33.6%	-0.48	-50.1%
22	Belgium	0.88	-0.28	-32.1%	-0.43	-49.0%
23	Ireland	0.86	-0.14	-16.3%	-0.20	-23.5%
24	Philippines	0.78	-0.18	-23.1%	-0.26	-33.5%
25	Taiwan	0.68	-0.21	-31.3%	-0.30	-44.2%
26	United Kingdom	0.62	-0.22	-35.4%	-0.31	-50.7%
27	Japan	0.62	-0.28	-46.0%	-0.40	-63.9%
28	Singapore	0.61	-0.19	-31.0%	-0.27	-44.3%
29	Papua New Guinea	0.59	-0.03	-5.2%	-0.06	-9.9%
30	Italy	0.57	-0.25	-43.4%	-0.34	-60.3%

Note: Only countries with 2017 export sales to China exceeding $500 million are shown. Results for the complete list of countries are reported in Online Appendix Table A4, with other growth scenarios shown in Tables A5-A6.

Table 6: Forecast of China's Import Demand for Coarse Grains (except corn), Zero growth from 2017

Country	No Subsidy 2020 & 21 Million US$	Subsidy=42% Difference from 2020 Million US$	Percent	Subsidy=59% Difference from 2021 Million US$	Percent
United States	918.2	117.7	12.8%	228.0	24.8%
ROW	2,814.3	-290.5	-10.3%	-470.0	-16.7%
Australia	1391.0	-143.6	-10.3%	-228.8	-16.4%
Canada	324.6	-71.8	-22.1%	-121.2	-37.3%
Ukraine	129.1	-39.4	-30.5%	-71.1	-55.1%
France	47.3	-31.7	-67.0%	-44.8	-94.7%
Denmark	1.5	-1.5	-100.0%	-1.5	-100.0%

Note: Only countries with 2017 export sales to China exceeding $1 million are shown, though the ROW total is computed over all countries besides the United States. Results for the list of countries exporting coarse grains to China in 2017 with sales over $50,000 are reported in Online Appendix Table A7.

Table 7: Forecast China's Import Demand for Soybeans, Zero growth from 2017

Country	No Subsidy 2020 Million US$	Subsidy=42% Difference from 2020 Million US$	Percent	Subsidy=59% Difference from 2021 Million US$	Percent
United States	13,858.8	289.2	2.1%	529.7	3.8%
ROW	25,569.5	-151.5	-0.6%	-37.0	-0.1%
Brazil	20,873.2	-99.4	-0.5%	-104.4	-0.5%
Argentina	2,644.0	-110	-4.2%	-121.5	-4.6%
Uruguay	990.7	-47.6	-4.8%	-1.5	-0.2%
Canada	886.3	2.7	0.3%	46.1	5.2%
Russia	158.4	20.6	13.0%	30.7	19.4%
Ukraine	9.2	8.2	88.4%	6.5	70.5%
Ethiopia	4.5	44.7	>100%	63.6	>100%
Kazakhstan	2.8	0.4	13.0%	0.6	21.2%
Germany	0.2	8.4	>100%	12.1	>100%
Mozambique	0.1	8.4	>100%	12.1	>100%

Note: Only countries with 2017 export sales to China exceeding $50,000 are shown.

Table 8: Forecast of China's Import Demand for Rapeseed, Zero growth from 2017

Country	No Subsidy 2020 Million US$	Subsidy=42% Difference from 2020 Million US$	Percent	Subsidy=59% Difference from 2021 Million US$	Percent
ROW	2,100.2	-246.6	-11.7%	-336.9	-16.0%
Canada	2,035.1	-239.6	-11.8%	-320.1	-15.7%
Mongolia	26.7	-0.2	-0.6%	-0.4	-1.4%
Australia	25.8	-6.6	-25.7%	-16	-62.2%
Russia	12.6	-0.2	-1.5%	-0.4	-3.2%

Note: All countries with 2017 export sales of rapeseed to China are shown.