China's Growth and the Agricultural Exports of Southern Africa

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Abstract

The implications of China's growth for the development prospects of sub-Saharan Africa have been the subject of recent attention. Interest in this topic is motivated by the increasing presence of China in the region, which in turn is reflected in the growing bilateral trade links. Against this background, this paper explores whether China's growth has stimulated agricultural exports in selected countries of Southern Africa, namely, Malawi, Mozambique, Tanzania, the SACU, and Zambia. We find little complementarity between China's agricultural import demand and the Southern African countries' agricultural export supply. We also explore the possibility of China affecting Southern African agricultural exports through higher world agricultural prices associated with China's growing demand for food. We find that, although China has moderately increased agricultural prices (in an aggregated sense), Southern African exports do not seem to benefit from these price increases.

1 Introduction

This paper explores the impact of China's economic growth on the agricultural exports of selected Southern African (SA) countries. The study can be framed within the broader body of literature dealing with the implications of China's growth for the development prospects of sub-Saharan Africa[1]. A main conclusion from the literature is that the involvement of China in Africa is driven by China's need to ensure access to natural resources. Furthermore, this involvement is complex, encompassing political cooperation, investment, aid, and trade. It is precisely in the trade area where the effects of a closer relationship between China and Africa are more evident. During the period 2004-2007, African exports to China increased at an average rate of 46.1% per year, positioning China to be Africa's third largest export market after the E.U. and the U.S. (Besada, Wang, and Whalley, 2008). However, these aggregate figures mask the fact that the growth in Africa's exports to China is driven by the few countries that export oil and other metals and minerals.

In 2007, the exports of oil and related products from Angola, Sudan, Congo, and Equatorial Guinea accounted for 60% of all African exports to China (Besada, Wang, and Whalley, 2008, Table 1, p.8). South Africa's exports alone, most of which are diamonds, accounted for 18%. For the majority of these countries, China's growth has implied an improvement in their terms of trade. Zafar (2007, Table 1, p .111) indicates that during the period from 2002 to 2005, Angola's terms of trade[2] increased by 26.5%, Sudan's by 18.7%, Congo's by 23.9%, and Equatorial Guinea's by 93.7%. Zambia, an exporter of copper, saw its terms-of-trade increase by 23.4%. A natural question that arises from these trends is why focus on agriculture when most of the effects seem to be concentrated in oil, metals, and other mineral resources.

The answer lies in two facts. First, a considerable number of African countries are not oil exporters, but rather specialize in agriculture. In the specific case of Southern Africa, 79.5% and 56.7% of Malawi's and Tanzania's exports are agricultural and food products[3]. Second, China (along with India and other developing countries) is often seen as a source of inflationary pressure on food prices due to growing demand. To the extent that China exerts upward pressure on world food prices, food exporters may benefit.

Besides Malawi and Tanzania, this analysis covers Mozambique, Zambia, and the countries of the Southern African Custom Unions[4], which are treated as an entity due to trade data availability[5]. The next section discusses the structural differences between China's import demand and the export supplies of these countries. The main conclusion is that their agricultural exports to China are almost nonexistent. In this sense, there is no reason to expect an impact from China's growth on SA's agricultural exports. However, given the possibility of indirect effects through global prices, we undertake an econometric analysis that gives a sense of the upward pressure on food prices attributable to China's growth, and we also investigate China's influence on agricultural exports of the focus countries.

Our econometric strategy, fully developed in Sections 3 and 4, is derived from the gravity model proposed by Anderson and van Wincoop (2003). This model has several advantages for our purposes. First, it has been developed from the demand side with an Armington specification whereby demand is differentiated by product origin. The model is also compatible with a number of specifications on the supply side. These features avoid the need for making assumptions about preferences and production that could be at odds with the sources of product differentiation in the agricultural sector (e.g., love of variety models). Second, and crucial for this study, the price indices of the CES function that underlie the gravity model allow us to capture the broad price effects of China.

2 China's Import Demand and Southern Africa's Export Supply of Agricultural Products

For the last few years, China has consistently ranked among the 10 top world importers of agricultural products[6]. Figure 1 shows that since 1998 China has steadily increased its share of world food imports, going from 1.15% in 1998 to 3.49% in 2004[7]. Nevertheless, China's share of world food markets (2.51% on average for the period 2000-2004) is small when compared with that of the world's top food importers such as the U.S. (11.64%), Japan (9.59%), Germany (8.2%), Great Britain (6.41%) and France (5.75%).

[INSERT FIGURE 1 ABOUT HERE]

Table 1 shows the union set of the 20 top agricultural products (according to the four digit classification of the Harmonized System) imported by China in 1995, 2000, and 2004. These products accounted for 85.73%, 70.47%, and 78.26% of China's total agricultural imports in 1995, 2000, and 2004, respectively. Two general patterns are apparent. First, China's imports are concentrated in a few products, notably soybeans, soybean oil, and palm oil, which accounted for 47.4% of China's total agricultural imports in 2004. Second, China's import patterns have changed over time. Specifically, in 1995, wheat and corn combined represented 29.81% of total food imports, while by 2004, these staples represented only 7.48%. Consistent with the import specialization in oilseeds and grains, more than half of China's agricultural imports come from Brazil, the U.S., and Canada. Malaysia and Thailand are also important providers of oilseeds to China.

[INSERT TABLE 1 ABOUT HERE]

There are practically no agricultural exports going from the Southern African countries to China. Both the share of Southern African products in China's total food imports and the share of China in Southern African agricultural exports are negligible ($< 1\%$). This fact has important implications for our work. In principle, we can rule out any direct effect of China's growth in food demand on the exports of Southern Africa. However, as mentioned in the introduction, it is still possible that SA countries benefit indirectly from China-induced higher food prices.

If China is a source of higher food prices, there are two ways through which Southern Africa could see an increase in its export values. First, if the products that China demands overlap with the products that SA supplies, the SA countries will benefit from higher prices even if they sell in markets other than China. Second, if China's demand and SA's supply have little in common, China's inflationary effects could spill over beyond the products they import directly because of complementarities in production and consumption. The first possibility is explored in the rest of this section. The latter is more complex to grasp, and we will revisit it in the next sections.

Turning our attention to the first possibility, i.e., that the countries of Southern Africa have a supply that overlaps with China's demand, Table 2 shows for each SA country the union set of the five top agricultural export products in 1995, 2000, and 2004. In 2004, these products represented 81.69% of total agricultural exports in Zambia, 85.16% in Mozambique, and 95.26%. The share of this set in total exports is lower in Tanzania (67.53%) and the SACU (48.41%), showing that these countries have more diversified product baskets.

[INSERT TABLE 2 ABOUT HERE]

Comparing the products of this table with the products in Table 1, it is striking to see how limited is the coincidence between China's import demand and Southern African countries' export supply. In particular, none of the top exports of Tanzania appear as top imports of China. The only important export of the SACU, Malawi, and Zambia that is also imported by China is sugar cane (HS4 1701). However, note that sugar cane is only 1% of China's imports. Besides sugar, Mozambique also exports fish products (HS 306), which are a much reduced fraction (1%) of China's total food imports. So, on the surface, it looks as though the effects of China on SA's exports due to direct demand are negligible. It is also apparent that there is no overlap between SA's agricultural supply and China's agricultural demand in third markets. This leaves the potential inflationary pressures attributable to China's growth in demand as the only channel through which China can affect the exports of the African countries. To study this channel, we need a formal model, which is discussed next.

3 Theoretical Framework

We use the theoretical framework proposed by Anderson and van Wincoop (2003, 2004)[8] to identify the price effects of increases in China's demand for food. This framework offers two main advantages for our work. First, it is general enough to accommodate various interpretations of the source of specialization in the supply side (e.g., national origin or monopolistic competition). Second, AvW's treatment of the CES price indices allows capturing the price effects of China's demand on the demands of other countries importing from SA. As suggested by our exploration of the data, these indirect effects are key because the direct exports from SA to China are quite limited.

Following the exposition in Anderson and van Wincoop (2004, p.707), the CES demand structure[9] implies that the exports X from i to j in product class k are given by:

$$X_{ij}^k = \left(\frac{p_i^k t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} E_j^k \quad (1)$$

where σ_k is the elasticity of substitution among origins, p_i^k is the supply price in country i, t_{ij}^k are the power of trade costs such that $t_{ij}^k - 1$ is the ad-valorem tax equivalent of trade costs, E_j^k is the expenditure of j in product k, and P_j^k is the CES price index in the importing country j:

$$P_j^k = \left[\sum_i p_i^k {t_{ij}^k}^{1-\sigma_k} \right]^{1/(1-\sigma_k)} \quad (2)$$

Anderson and van Wincoop (2004) impose the market clearing conditions $Y_i^k = \sum_j X_{ij}^k$, use them to solve the equilibrium supply prices p_i^k, and substitute the result in Equations 1 and 2 (see details in Appendix A). They present their resulting equilibrium in terms of production and expenditures relative to world output (i.e., E_j^k/Y^k, Y_i^k/Y^k with $Y^k = \sum_i Y_i^k = \sum_j E_j^k$). For convenience in the empirical implementation (more on this below), we slightly modified this equilibrium[10], stating it in terms of absolute productions and expenditures, obtaining the following version of Anderson and van Wincoop (2004, p.708)'s gravity equation:

$$X_{ij}^k = Y^k E_j^k Y_i^k \left(\frac{t_{ij}^k}{\tilde{\Pi}_i^k \tilde{P}_j^k} \right)^{1-\sigma_k} \tag{3}$$

subject to:

$$(\tilde{\Pi}_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} E_j^k \tag{4}$$

$$(\tilde{P}_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k} \right)^{1-\sigma_k} Y_i^k \tag{5}$$

Equation 3 explains the variability of bilateral trade flows in terms of exporters' supply, importers' demand, bilateral trade costs, and the equilibrium price indices $\tilde{\Pi}_i^k$ and $\tilde{P}_j^k$. AvW call these CES price indices multilateral resistance terms. These terms show that the volume of exports from i to j depends simultaneously on the trade barriers that j imposes on all its partners and on the trade barriers that i faces in all its markets. The first effect is captured by the *inward* multilateral term $\tilde{P}_j^k$; it shows that if j imposes a high trade barrier on i's competitors, i's will experience less resistance into j's market, and thus will export more to this market. The second effect is captured by the *outward* multilateral resistance term $\tilde{\Pi}_i$; it shows that increased barriers in i's destination markets relative to the barriers imposed by j will also stimulate the flow of i's exports to j.

The interdependence of the price terms is of direct interest for this paper. The variable summarizing the effects of China's growth on the exports of other countries is the expenditure value E_{China}^k. Equation 3 shows that exports from i to China grow proportionally with China's expenditures. This is an obvious result: demand increases with income. However, as discussed in the previous section, the direct exports of the focus countries to China are of limited significance. Because of this, of more interest are the indirect effects that China can have on a country's demand, given China's potential influence on global prices. In the framework of AvW, this influence is captured by the price terms.

For instance, an increase in China's expenditures (E_{China}^k) in Equation 4 reduces the price index $\tilde{\Pi}_i^k$. Equation 3 indicates that a decrease of $\tilde{\Pi}_i^k$ is associated with a decrease in the bilateral exports from i to j ($\forall j \neq China$). We can look at this reduction from two perspectives. First, because of the equilibrium condition $Y_i^k = \sum_j X_{ij}^k$, an increase of the exports from i to China, keeping i's production (Y_i^k) constant, will in general divert exports from i to other destinations. From the perspective of the resistance to trade, an increase in China's expenditures decreases the multilateral resistance facing all the suppliers in China's market (in Eq. 4 an increase in E_{China}^k is equivalent to a decrease in the trade barrier $t_{i,China}^k$). This is ultimately reflected in the decrease of the outward multilateral resistance term of each country $\tilde{\Pi}_i^k$. Just as higher resistance to i's shipments in other markets increases the exports of

i to j, lower resistance diverts these exports.

In the equilibrium of AvW, lower $\tilde{\Pi}_i^k$s following an increase in E_{China}^k, increases the price index of importer j, $\tilde{P}_j^k$s. In terms of multilateral resistance, this implies that the relative barriers of j have increased, thus giving i a price advantage that is ultimately reflected in more exports from i to j. Another perspective can be obtained from Equation 2, which shows that, keeping trade costs constant, the increase in $\tilde{P}_j^k$ is explained by an increase in i's supply prices, p_i^k. This is precisely the effect that we will be looking at more closely as it will capture whether China's increases in demand have pushed up world prices, thus benefiting SA countries even if they do not export directly to China.

Summarizing the intuition behind these informal comparative statics, we have an increase in China's expenditures translating into an increase in the Chinese demand for product k. This increase in demand exerts pressure on the supplies, thus driving prices up. Higher prices have two effects that work in different directions. First, they decrease the demand for i's products; this is the reducing effect of an increase in E_j^k on $\tilde{\Pi}_i^k$ and ultimately on X_{ij}^k. At the same time, the increase in demand drives i's supply prices up, thus potentially increasing the exports of i to j; this is the increasing effect of an increase in E_j^k on $\tilde{P}_j^k$ and ultimately on X_{ij}^k. In the absence of strong direct links between China and the SA countries, we will explore if China's increased demand has contributed to an environment of higher world prices such that the African countries benefit indirectly from China's growth; hence, our main interest is in the changes in $\tilde{P}_j^k$ and its effect on exports.

Our general strategy is to trace the evolution of E_{China}^k, where k refers to aggregated agricultural goods. With the temporal evolution of expenditures at hand, we calculate the prices that would sustain observed exports in the absence of growth in China's expenditures. This entails solving Equation 3 subject to Equations 4 and 5. From the comparative statics, we would expect that in the absence of China's growth, the outward multilateral resistance term for each country i would increase, decreasing the price index P_j reflecting a reduction of i's supply price. Once we obtain the equilibrium prices with China's attenuated expenditures, we use Equation 3 to recover the bilateral exports of each country i. These simulated exports should be lower than the observed exports as long as China is an important destination (simply because we reduced China's expenditures). In the absence of strong ties with China, the simulated exports should be lower than the observed exports as long as the reductions in supply prices overcome the increases in outward multilateral resistance associated with reduced expenditures.

A caveat to be noticed is that the analysis is partial equilibrium in nature. The first reason is that we focus solely on agricultural products abstracting from interactions between productive sectors. For example, Abbot, Hurt, and Tyner (2008) argue that China is connected to higher food prices not through increased food demand, but through the increases in oil prices that are in turn linked to food prices through biofuel policies. We abstract from such interactions. Another partial equilibrium feature of our work is that in predicting the trade patterns (simulated exports) that would prevail in the absence of China's expenditure growth, we do not take into account wage effects that could come from cheaper food, thus impacting trade patterns in ways that are not obvious. This implies that the estimates we obtain below should be considered the upper bound of the potential effects linked to China's growth.

4 Empirical Implementation

We use import data (from the UN's Comtrade database) on the aggregated agricultural sector, comprised of the first 24 chapters of the Harmonized System. This level of aggregation is consistent with our objective of identifying in the data the generalized price effects attributable to China's increased demand for agricultural products. In order to get a period long enough for the potential effects of China's growth to manifest themselves, the data cover the period 1995-2006. The data included are the imports and exports of a consistent set of 70 countries that cover most of the global trade in agricultural products. Because we will be comparing parameter estimates from different years, only those transactions that are positive every year during the period 1995-2006 are included.

The empirical strategy consists of identifying China's expenditures by taking advantage of the differences in China's import values across exporters. To accomplish this, we start by taking natural logarithms of Equation 3 and rearrange to get[11]:

$$\log(X_{ij}) = \log(Y) + \log\left(\frac{E_j}{\tilde{P}_j^{1-\sigma}}\right) + \log\left(\frac{Y_i}{\tilde{\Pi}_i^{1-\sigma}}\right) + (1-\sigma)\log(t_{ij}) \tag{6}$$

where all variables have been previously defined. Differing from Anderson and van Wincoop (2003), we do not impose unitary income elasticities on Equation 6[12]. This allows us to have the expenditures explicit on the right hand side of Eq. 6. Although data on expenditures and production could be obtained with some effort, the price indices are unobservable. In the original work of Anderson and van Wincoop (2003) these price indices are recovered by assuming symmetric trade costs and minimizing the sum of squares of an equation similar to 6, subject to the price equations. A simpler alternative suggested by AvW and discussed in Feenstra (2002) is to use exporter and importer fixed effects to account for the unobserved price indices. The fixed effects are especially appealing in our framework because they would capture not only differences in the unobservable price indices, but also differences in expenditures and production.

Following standard practice, and in an analogous way to AvW, we define the trade costs (t_{ij}) as a multiplicative function of distance between partners and other factors that are known to condition bilateral trade flows such as border ($BORD_{ij}$) and language ($LANG_{ij}$) commonality, whether the countries are both landlocked ($LOCK_{ij}$), whether they belong in the same preferential trade agreement (PTA_{ij})[13], and other factors (ϵ_{ij}). Then t_{ij} can be written as:

$$t_{ij} = (DIST_1^{\delta} e^{\delta_2 BORD_{ij} + \delta_3 LANG_{ij} + \delta_4 PTA_{ij} + \delta_5 LOCK_{ij} + \epsilon_{ij}}) \tag{7}$$

Denoting the country fixed effects by EXP_i (for exporters) and IMP_j (for importers), the estimating equation is:

$$\begin{aligned} \log(X_{ij}) = \beta_0 + \sum_i \alpha_i^X EXP_i + \sum_j \alpha_j IMP_j + \beta_1 \log(DIST_{ij}) + \beta_2 BORD_{ij} \\ + \beta_3 LANG_{ij} + \beta_4 PTA_{ij} + \beta_5 LOCK_{ij} + (1-\sigma)\epsilon_{ij} \end{aligned} \tag{8}$$

Where β_0 is an intercept, $\alpha_i^X = \log(Y_i/\tilde{\Pi}_i^{1-\sigma})$, $\alpha_j^M = \log(E_j/\tilde{P}_j^{1-\sigma})$ and $\beta_i = (1-\sigma)\delta_i$ are parameters to be estimated, and ϵ_{ij} is a stochastic error assumed to have a zero mean and not to be correlated with any of the regressors.

The trade data X_{ij} on the left hand side of Equation 8 are the imports described above. The distance between exporter and importer is measured in kilometers, according to the great circle formula. The rest of the conditioning factors are each measured with a dummy variable that takes the value of one when a pair of countries share a border, speak the same language, are both landlocked, or belong in the same preferential trade agreement, and zero otherwise. Information on the 65 existing PTAs was obtained from Fontagne and Zignago (2007). The rest of the data come from Mayer and Zignago (2006).

5 Results and Discussion

Equation 8 is estimated using Ordinary Least Squares for each year during the period 1995-2006. Full sets of fixed effects are used for both importers and exporters. The U.S. is used as the omitted category. This implies that the measures of supply (output deflated by i's price index) and demand (expenditures deflated by j's price index) are relative to the average level of (the log of) bilateral US imports and exports. The output of the regressions is shown in Table 3.

[INSERT TABLE 3 ABOUT HERE]

The sectoral gravity models work as expected. For instance, the negative coefficient on distance implies that countries that are farther apart trade less. Countries that share a border, speak the same language, or are both landlocked tend to trade more than countries that do not share these characteristics. So do countries that belong in the same trade agreement, although this effect seems to be more evident in the more recent years. For the most part, these coefficients are stable over time, economically important, and statistically significant. The last row of Table 3 shows the R^2 values. They indicate that the models explain on average over three fourths of the level of variation in bilateral trade.

To recover the estimates of $\tilde{\Pi}_i$, Equation 4 is rewritten using the estimated trade costs[14] $\widehat{t_{ij}^{1-\sigma}}$, the estimated importers' fixed effects $\hat{\alpha}_j^M$, and the fact that $\alpha_j^M = \log(E_j/\tilde{P}_j^{1-\sigma})$. This yields:

$$\widehat{\Pi_i^{1-\sigma_k}} = \sum_j e^{\hat{\alpha}_j^M} \widehat{t_{ij}^{1-\sigma}} \tag{9}$$

Likewise, the empirical importers' price indices ($\hat{P}_j$) are obtained by combining $\widehat{t_{ij}^{1-\sigma}}$, the estimated exporters' fixed effects $\hat{\alpha}_i^X$, and the fact that $\alpha_i^X = \log(Y_i/\tilde{\Pi}_i^{1-\sigma})$, thus obtaining the empirical counterpart of Equation 5:

$$\widehat{P_j^{1-\sigma_k}} = \sum_i e^{\hat{\alpha}_i^X} \widehat{t_{ij}^{1-\sigma}} \tag{10}$$

Now that we have the price indices, we solve the importers' expenditures $\hat{E}_j$ and the exporters' outputs $\hat{Y}_i$ using the estimated fixed effects $\hat{\alpha}_j^M$ and $\hat{\alpha}_i^X$[15].

Figure 2 shows China's importer fixed effects (in the upper panel) and food expenditures (in the lower panel) obtained as outlined above. The latter are indexed such that the value in year 1995 is unity. Notice that these fixed effects are negative, indicating that China's imports of agricultural products are below the average US level of agricultural trade. As we move towards the more recent years, the estimated fixed effects grow (become less negative). In the lower panel of Figure 2, the expenditures, as inferred from the regression coefficients, declined during 1996 and 1997, coinciding with the regional recession associated with the Asian financial crisis. After that, expenditures recovered, and by 2003, they were 3.5 times larger than in 1995. The figure shows a decline from 2003 to 2004, a slight recovery in 2005, and a new contraction in 2006. This roughly agrees with Gale's assertion that China's agricultural imports from the U.S. boomed during 2003-2004, although he registers the peak in 2004; our figures are not directly comparable because his are nominal, while ours are real in the sense that they are relative to the trade behavior of the U.S. For our purposes, the relevant fact is that by 2006, China's expenditures on food were two times larger than in 1995.

[INSERT FIGURE 2 ABOUT HERE]

With these estimates of the temporal evolution of China's food expenditures, we can answer the question posed in the introduction: Does China's growth — through increases in demand for agricultural products — imply more agricultural exports from Southern Africa? To answer this question, we simulate the exports that would have prevailed in 2006 if China's demand had stagnated at its 1995 levels. The idea is that, if China's demand is related to increased exports in SA, a stagnation in China's demand should result in lower SA exports. The comparison of the simulated and observed exports gives an idea of the effects related to China's growth. We try to capture both the direct and indirect effects. To see this more clearly, we can sum over j the bilateral exports of i given in Equation 3, obtaining:

$$X_i = Y \frac{Y_i}{(\tilde{\Pi}_i)^{1-\sigma}} \sum_j \left[\left(\frac{t_{ij}}{\tilde{P}_j} \right)^{1-\sigma} E_j \right] \tag{11}$$

A first order effect is through the direct sales to China, as evidenced by the term E_j within the summation on the right hand side of Equation 11. Hence, our first step in the simulation is to substitute China's expenditures in 1995 for China's expenditures in 2006 in every bilateral transaction of exporter i with China. The expenditure terms also affect total exports in (11) through their effects on the exporters' price indices $\tilde{\Pi}_i$ discussed in Section 3-Eq. 4. In an analogous way, we recalculate these indices by substituting China's expenditures in 1995 for the expenditures in 2006. Another indirect effect of a change in expenditures is through the effect of the newly recalculated $\tilde{\Pi}_i$s on the importers' price indices, $\tilde{P}_j$; thus, we have to calculate new $\tilde{P}_j$s.

As mentioned before, the equilibrium implied by AvW's model requires simultaneous estimation of the price indices. Our approach is to find the counterfactual set of price indices $[\widehat{\Pi_{ci}^{1-\sigma}}, \widehat{P_{cj}^{1-\sigma}}]$ (the subscript c emphasizes the counterfactual nature of these indices) that minimize the sum of squared residuals (SSR) of Equation 8, given the parameter estimates of trade costs (distance, border, etc.) discussed at the beginning of this section (see Table 3) and the set of production and expenditure values $[\hat{Y}_i, \hat{E}_j]$ recovered from the exporter and importer fixed effects. [16].

The minimization exercise yields an SSR of 5,277.46, slightly above 5,241.09, the SSR of the original regression. A main consequence of holding China's expenditures constant at 1995 levels is to reduce across the board all the importers' fixed effects. We can rewrite the importer fixed effect as:

$$\alpha_j^M = \log(E_j) + \log(P_j^{\sigma-1})$$

Which shows that keeping E_j constant, a reduction of α_j^M implies a reduction of $P_j^{\sigma-1}$. This is consistent with our discussion in Section 3, where a reduction in E_{China} will reduce the importer price indices P_j implying a reduction of the import price at each location j, and therefore of the supply price received by exporters in i.

The first two columns of Table 4 show the first 20 countries with the largest importer fixed effects before and after the simulation, the difference between the fixed effects, and how much that difference represents (in percentage terms) out of the original values. This last measure is an indication of how much higher prices are at destinations j as a consequence of China's increased demand for food. The first country is of course China, where in the absence of demand growth, the CES price index would be 51.3% lower. Japan follows whith an estimated "inflationary" effect attributable to China's growth of about 10%. Then are Germany (4.2%), England (2.9%), and other large Asian and European economies in which the CES price index is between 1.5% and 2.5% higher as a consequence of China's growth. The first 10 economies in Table 4 are among the world's largest food importers; thus, it is not surprising that it is in these economies where price rises associated with more competition with China for (presumably in the short-run) fixed supplies of food are the largest. It should be kept in mind that these are aggregated effects; thus, these values represent the increase in *all* food prices.

[INSERT TABLE 4 ABOUT HERE]

The exporter fixed effects also change after the simulation. Recapitulating our discussion in Section 3, a decrease in E_{China} increases the multilateral resistance facing exporter i ($\tilde{\Pi}_i$). To see how changes in $\tilde{\Pi}_i$ affect the exporter fixed effects, rewrite them as:

$$\alpha_i^X = \log(Y_i) + \log(\Pi_i^{\sigma-1})$$

This expression shows that by holding output (Y_i) constant, the increase in Π_i equals the increase in the simulated exporter fixed effects. These larger fixed effects have a positive effect on the exports from i to j, and thus, they work in an opposite direction from the changes in the importer fixed effects. This is a consequence of the market equilibrium underlying AvW's model, whereby the reduction in exports to the country spending less (i.e., China) must be compensated with increases in exports to the rest of the destinations.

Table 5 shows the first 20 countries with the largest change in the exporter fixed effect. The first country is Brazil, in which the percentage change in the fixed effects is 13.6%, implying that the multilateral resistance term faced by this country increased by this much. These increases in the multilateral resistance imply that, if China had not grown the way it did and, keeping national outputs constant, countries such as Brazil would be exporting more to countries other than China. Notice that the countries with the largest increase in their multilateral resistance terms are countries with large exports of a reduced number of agricultural commodities such as Brazil (soybeans), Argentina (soybeans, corn), Malaysia (palm oil), and Indonesia (palm oil). This suggests that it is for these countries that China's effects on agricultural exports are more important.

[INSERT TABLE 5 ABOUT HERE]

The changes in the importer and exporter price indices just discussed are the changes in prices needed to obtain the *observed* bilateral exports in the presence of China's attenuated demand. However, we can also use them to infer how different would have been the exports from SA countries with China's stagnated demand. To this end, using the parameter estimates of Equation 8 and the terms recovered from them throughout this section, we rewrite a counterfactual version of Equation 11 as:

$$X_{ci} = e^{\hat{\beta}_0} \frac{\hat{Y}_i}{\widehat{\Pi_{ci}^{1-\sigma}}} \left[\sum_{j \neq China} \left(\frac{\widehat{t_{ij}^{1-\sigma}}}{\widehat{P_{cj}^{1-\sigma}}} \right) \hat{E}_j + \left(\frac{\widehat{t_{i,China}^{1-\sigma}}}{\widehat{P_{cChina}^{1-\sigma}}} \right) \hat{E}_{cChina} \right] \tag{12}$$

Where X_{ci} are the total exports of country i that would have prevailed (hence the subscript c for counterfactual) in the absence of China's demand growth. As explained before, the first order effect of a stagnation in China's demand is through $\hat{E}_{cChina}$ (i.e., China's expenditures in 1995), explicit within the summation symbol of Equation 12. To assess the importance of this channel, Equation 12 is first calculated using the original (as opposed to counterfactual) $\widehat{\Pi_i^{1-\sigma}}$ and $\widehat{P_j^{1-\sigma}}$. The resulting exports are then subtracted from the observed exports (shown in the first column of Table 6), and the difference is expressed as a percentage of the latter. The results are in the second column of Table 6. In line with our discussion in Section 2, the impact on the countries of Southern Africa is practically null; that is, the difference between observed total exports and simulated exports for Malawi, Mozambique and Zambia is zero, while it is slightly negative for the SACU (-0.4%). For Tanzania, the effect is a little bit larger; if China's food expenditures had stagnated at its 1995 levels, Tanzania's agricultural exports would be -1.40% lower.

[INSERT TABLE 6 ABOUT HERE]

Due to the potential effects on world prices, we argue that there may be indirect effects benefiting Southern African exporters. Our discussion of the importer fixed effects confirmed that in a few developed countries, China's increased demand for food has been a source of price inflation; it would be expected then that SA countries exporting to these countries would benefit from higher prices. To be able to assess the relative importance of these indirect effects, the third column of Table 6 shows the results of repeating the exercise outlined in the paragraph above, but now using $\widehat{P_{cj}^{1-\sigma}}$ instead of $\widehat{P_j^{1-\sigma}}$. The results are shown in the third column of Table 6. These percentages capture both the first order effects discussed in the previous column and the indirect effects through changes in global prices. Notice that the indirect effects are now discernible in the data. For instance, Malawi would have exports 3.58% lower than observed if China's expenditures had not grown since 1995. The results are similar for Mozambique (-3.58%), Tanzania (-5.15%), Zambia (-4.01%), and the SACU (-4.01%). In principle, it would be tempting to link these results to a generalized effect of China on world food prices; however, given the level of aggregation in the data, it is quite possible that the results are rather artificial. To see this more clearly, we could assume that China's effects are limited to oilseeds. In the aggregate data, an increase in the price of oilseeds appears as a diluted increase in the price of all food products. Then we are valuing the SA exports with this effect, even if the SA countries do not export oilseeds.

By way of contrast, Table 6 shows the simulated exports of other developing countries in Asia and Latin America. For instance, considering only a contraction in China's expenditures, Indonesia's agricultural exports are 7.37% lower than observed. When we consider the indirect effect of China on world supply prices, the stagnation of China's expenditures resulted in exports 10.52% lower than observed. The results for Malaysia are similar. In Latin America, the contraction of the exports ranges from 7.29% in Argentina to 9.64% in Peru. As in all the other cases, the indirect effects account for additional diminution of approximately 3.5%. This comparison shows that the data combined with the model of AvW can effectively capture the effects of the changes in China's expenditures.

6 Conclusions

The objective of this paper was to answer a simple question: Does China's growth stimulate more agricultural exports from Southern Africa? Our exploration of the import and export structure of China and the countries in Southern Africa revealed that there is little overlapping between China's import demand and the Southern Africa countries' export supply; hence, via direct transactions, the effects of China on Southern Africa are limited. However, China is a large country and there is a possibility that its increases in demand did have an effect on world prices. In this context, it is possible for African exporters to benefit from the China-induced higher prices, even if they do not sell their products directly to China, which would require that the African countries specialized in what China demanded. In the description of the data we found little evidence that this is the case. Yet a third possibility is that China's pressure on agricultural supplies has a generalized effect on food prices, regardless of whether China imports them directly from the Southern African countries.

The framework of choice for capturing and separating the direct and indirect effects of China was the gravity model proposed by Anderson and van Wincoop (2003), applied to the agricultural sector. This framework is general enough to accommodate several supply-side structures, allowing us to focus on the demand side. Using aggregated data on trade in agricultural products for the period 1995-2006, we used the model to trace the evolution of China's expenditures during the last decade. Then, for each of our focus countries, we simulated the exports that would have prevailed if China's demand for food had not grown since 1995.

Our results suggest that China has been a source of aggregated mild price inflation in the largest developed economies that occupy the first ranks of food importers. This is probably related to a more intense pressure on world food supplies. When we looked at the counterfactual exports of Southern

African countries, we found that the effects are null. However, when we take into account the indirect effects, we found that if China had not grown the way it did during the last decade, Southern African agricultural exports would be from 3.5% to 5.15% smaller. We are cautious about these results given the level of aggregation in the data. We contrasted our results with those of other developing countries that export oilseeds, oil meals, and grains and found that the direct effects of China's increased expenditures are significant and can be detected in the data. These elements suggest that the answer to our question is negative.

Notes

[1]See for example Goldstein et al. (2006), Zafar (2007), Kaplinsky and Messner (2008), and Besada, Wang, and Whalley (2008).

[2]Export prices divided by import prices.

[3]Average 2000-2005 from The World Bank (2007)

[4]Botswana, Lesotho, Namibia, Swaziland, and South Africa

[5]Until the year 2000, the countries of the SACU reported their trade statistics together

[6]This section is based on the trade data retrieved from the UN's Comtrade Database, and used later on the econometric exercise. Agricultural products are defined as the first 24 chapters of the Harmonized System. These chapters comprise the bulk of the agricultural products defined in the WTO Uruguay Agreement on Agriculture.

[7]The discussion is confined to 1995-2004 because it is for this period that we have a complete set of partners and reporters. The econometric analysis is extended to 2006, but using only a representative group of countries in 2005 and 2006.

[8]Thereafter AvW.

[9]A CES representation of consumer preferences is generally used to derive the gravity equation.

[10]See Appendix B for details.

[11]From now on we omit the subscript k as it is understood that we are focusing on the agricultural sector as a whole.

[12]The imposition of unitary income elasticities implies that the regressand is $\log(X_{ij}/E_jY_i)$, i.e., the log of exports divided by the product of the income/production terms.

[13]This is a crude proxy for applied bilateral tariffs which are not available to us for the period considered here.

[14]As is customary, we denote estimates with a hat $\hat{\cdot}$ The hat covers the term $1-\sigma$ because we recover the trade costs using: $DIST_{ij}^{\hat{\beta}_1} e^{\hat{\beta}_2 BORD_{ij} + \hat{\beta}_3 LANG_{ij} + \hat{\beta}_4 PTA_{ij} + \hat{\beta}_5 LOCK_{ij}}$. Because $\beta_i = (1-\sigma)\delta_i$, the result of this operation is $\widehat{t_{ij}^{1-\sigma}}$.

[15]I.e., $\alpha_j^M = \log(E_j/\tilde{P}_j^{1-\sigma}) \Rightarrow E_j = e^{\hat{\alpha}_j^M} \widehat{P_j^{1-\sigma}}$ and $\alpha_i^X = \log(Y_i/\tilde{\Pi}_i^{1-\sigma}) \Rightarrow Y_i = e^{\hat{\alpha}_i^X} \widehat{\Pi_i^{1-\sigma}}$.

[16]The GAMS program employed for this is available upon request. The initial values for the unknown $[\widehat{\Pi_{ci}^{1-\sigma}}, \widehat{P_{cj}^{1-\sigma}}]$ were the indices $[\hat{\Pi}_i, \hat{P}_j]$ whose estimation was discussed above. The subscript c is to emphasize the counterfactual nature of the new price indices.

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Table 1: China's main agricultural imports (as % of total agricultural imports)

Code HS-4	Product Description	1995	2000	2004
1201	Soybeans, whether or not broken	0.79	23.85	31.82
1511	Palm oil & its fractions, not chemically modified	9.07	4.79	8.52
1001	Wheat and meslin	21.25	1.55	7.48
1507	Soybean oil & its fractions, not chemic modified	10.74	1.32	7.06
303	Fish, frozen (no fish fillets or other fish meat)	3.22	7.19	6.92
2301	Flour, meal etc of meat etc, not for human greavs	3.46	6.65	3.51
2106	Food preparations nesoi	0.17	0.57	1.60
714	Cassava, arrowroot etc, fresh or dry sago pith	0.71	0.23	1.57
307	Molluscs & aqua invert nesoi, lve etc. flours etc	0.62	1.91	1.52
1003	Barley	2.52	3.29	1.46
306	Crustcns live fresh etc, ckd etc. flrs mls h cnsump	1.33	2.27	1.42
1701	Cane or beet sugar & chem pure sucrose, solid form	9.41	1.21	1.26
1006	Rice	4.55	1.18	1.15
1514	Rapeseed, colza or mustard oil etc, not chem modif	4.33	0.29	0.99
207	Meat & ed offal of poultry, fresh, chill or frozen	0.84	5.05	0.70
1205	Rape or colza seeds, whether or not broken	0.27	6.91	0.61
803	Bananas and plantains, fresh or dried	0.44	1.78	0.43
2402	Cigars, cigarettes etc., of tobacco or substitutes	3.45	0.41	0.24
1005	Corn (maize)	8.56	0.00	0.00

Source: UN Comtrade Database. Notes: The table shows the import value of individual agricultural products as a percentage of China's total agricultural imports. The products included are the union of the top 20 products imported by China in 1995, 2000, and 2004. The shares are sorted (in decreasing order) by their values in 2004.

Table 2: Main agricultural exports of Southern African countries (as % of total exports).

Partner	Code HS-4	Product Description	1995	2000	2004
Zambia	2401	Tobacco, unmanufactured tobacco refuse	11.00	20.48	36.97
	1005	Corn (maize)	6.56		18.78
	1701	Cane or beet sugar & chem pure sucrose, solid form	29.58	11.34	10.11
	603	Cut flowers & buds for bouquets etc., prepared	12.73	26.61	9.73
	708	Leguminous vegetables, shelled or not, fr or chill		9.60	6.09
	901	Coffee coffee husks etc substitutes with coffee	14.04	8.49	
SACU	805	Citrus fruit, fresh or dried	10.56	8.87	12.43
	2204	Wine of fresh grapes grape must nesoi		6.84	11.88
	806	Grapes, fresh or dried	7.03	7.13	10.01
	808	Apples, pears and quinces, fresh	8.55	5.11	7.74
	1701	Cane or beet sugar & chem pure sucrose, solid form	9.59	8.93	6.35
	2008	Fruit, nuts etc prepared or preserved nesoi	5.88		
Tanzania	304	Fish fillets & oth fish meat, fresh, chill or froz	8.36	28.79	24.00
	2401	Tobacco, unmanufactured tobacco refuse	7.83	12.07	17.12
	801	Coconuts, brazil nuts & cashew nuts, fresh or dry	21.87	9.34	12.04
	901	Coffee coffee husks etc substitutes with coffee	38.11	19.66	10.02
	1207	Oil seeds & oleaginous fruits nesoi, broken or not			4.37
	713	Leguminous vegetables, dried shelled	4.39		
	1512	Sunfl-seed, safflow or cottonsd oil etc, no ch mod		2.83	
Malawi	2401	Tobacco, unmanufactured tobacco refuse	77.55	71.80	68.60
	1701	Cane or beet sugar & chem pure sucrose, solid form	3.89	5.97	12.13
	902	Tea, whether or not flavored	7.04	17.48	10.19
	802	Nuts nesoi, fresh or dried			2.75
	713	Leguminous vegetables, dried shelled	1.63	0.65	1.58
	901	Coffee coffee husks etc substitutes with coffee	5.44	1.44	
Mozambique	306	Crustcns live, fresh etc, ckd etc. flrs mls h cnsump	48.09	49.32	37.02
	2401	Tobacco, unmanufactured tobacco refuse		9.64	17.68
	801	Coconuts, brazil nuts & cashew nuts, fresh or dry	13.87	13.79	15.50
	1701	Cane or beet sugar & chem pure sucrose, solid form	15.92	10.60	9.93
	1207	Oil seeds & oleaginous fruits nesoi, broken or not			5.03
	307	Molluscs & aqua invert nesoi, lve etc. flours etc		4.71	
	1005	Corn (maize)	6.72		
	1203	Copra	3.98		

Source: UN Comtrade Database. Notes: The table shows the value of specific agricultural products as a percentage of the total agricultural exports of the focus Southern African countries. The products included are the union of the top 5 products exported in 1995, 2000, and 2004. The shares are sorted (in decreasing order) by their values in 2004.

Table 3: Regression coefficients from gravity model. Country fixed effects are omitted.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Constant	26.224***	26.456***	26.591***	26.291***	26.394***	26.211***	26.379***	25.896***	25.789***	26.484***	26.560***	26.775***
	(0.514)	(0.512)	(0.487)	(0.495)	(0.492)	(0.464)	(0.451)	(0.460)	(0.450)	(0.464)	(0.461)	(0.466)
Log(Distance)	-1.170***	-1.179***	-1.184***	-1.150***	-1.177***	-1.149***	-1.180***	-1.131***	-1.109***	-1.192***	-1.216***	-1.223***
	(0.050)	(0.050)	(0.048)	(0.049)	(0.049)	(0.046)	(0.044)	(0.045)	(0.044)	(0.045)	(0.045)	(0.045)
Share border	0.569***	0.589***	0.620***	0.631***	0.562***	0.591***	0.594***	0.608***	0.634***	0.642***	0.673***	0.709***
	(0.165)	(0.157)	(0.153)	(0.153)	(0.155)	(0.159)	(0.146)	(0.146)	(0.145)	(0.140)	(0.141)	(0.139)
Common language	0.667***	0.679***	0.655***	0.665***	0.696***	0.637***	0.670***	0.719***	0.681***	0.669***	0.622***	0.610***
	(0.103)	(0.100)	(0.097)	(0.096)	(0.094)	(0.094)	(0.091)	(0.090)	(0.090)	(0.093)	(0.093)	(0.094)
Both landlocked	0.846***	0.872***	0.885***	0.907***	0.890***	0.902***	0.680***	0.613***	0.641***	0.517**	0.422*	0.301
	(0.233)	(0.216)	(0.232)	(0.246)	(0.219)	(0.206)	(0.196)	(0.199)	(0.204)	(0.212)	(0.240)	(0.259)
Trade Agreement	-0.317***	-0.243**	-0.182*	-0.068	-0.051	0.105	0.089	0.243***	0.310***	0.233***	0.127	0.059
	(0.110)	(0.107)	(0.103)	(0.105)	(0.105)	(0.098)	(0.093)	(0.091)	(0.089)	(0.088)	(0.089)	(0.090)
N	3114	3114	3114	3114	3114	3114	3114	3114	3114	3114	3114	3114
$RMSE$	1.479	1.435	1.400	1.396	1.350	1.314	1.287	1.309	1.296	1.308	1.336	1.328
R^2	0.717	0.727	0.733	0.728	0.744	0.754	0.761	0.757	0.761	0.768	0.758	0.759

The regressand is the log of bilateral imports. Robust standard errors in parentheses.
*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.10$

Table 4: Importer fixed effects before and after simulation from regressions for year 2006 (Top 20 countries).

	Observed ("Before")	Counterfactual ("After")	Difference	Difference as % of "Before"
China	−1.70	−2.57	0.87	51.28
Japan	−0.45	−0.49	0.05	10.36
Germany	−0.95	−0.99	0.04	4.17
Great Britain	−1.27	−1.31	0.04	2.99
Singapore	−3.07	−3.15	0.09	2.80
France	−1.47	−1.51	0.04	2.67
Indonesia	−2.56	−2.62	0.07	2.64
Spain	−1.48	−1.52	0.04	2.55
Netherlands	−1.61	−1.65	0.04	2.45
Italy	−1.63	−1.67	0.04	2.39
Korea	−2.12	−2.17	0.05	2.21
Australia	−2.03	−2.07	0.04	2.19
Malaysia	−3.23	−3.30	0.07	2.14
Hong Kong	−2.46	−2.51	0.05	1.99
Poland	−2.98	−3.02	0.04	1.32
New Zealand	−3.43	−3.48	0.04	1.30
Greece	−3.17	−3.21	0.04	1.27
Sweden	−3.15	−3.19	0.04	1.24
Denmark	−3.22	−3.26	0.04	1.21
South Africa/SACU	−3.15	−3.19	0.04	1.20

Source: Author's elaboration based on regression output. Notes: The first column is the importer fixed effects originally obtained from estimating Eq. 8 for year 2006. Next are the importer fixed effects obtained by minimizing the sum of squared residuals obtained by taking costs, expenditures and outputs as given, and reducing China's expenditures on food to its 1995 levels. Following are columns with the difference between "Before" and "After." The last column expresses this difference as a percentage of the original fixed effects. Because we hold expenditures constant, the reduction of these fixed effects is equivalent to a reduction in the prices of imported food in each country.

Table 5: Exporter fixed effects before and after simulation from regressions for year 2006 (Top 20 countries).

	Observed ("Before")	Counterfactual ("After")	Difference	Difference as % of "Before"
Brazil	−0.29	−0.25	−0.04	13.60
Argentina	−0.57	−0.53	−0.04	6.75
Hong Kong	−5.48	−5.22	−0.26	4.77
Malaysia	−2.13	−2.03	−0.09	4.46
India	−2.44	−2.33	−0.11	4.44
Indonesia	−1.90	−1.81	−0.08	4.29
China	−1.10	−1.06	−0.04	3.93
Japan	−3.86	−3.72	−0.14	3.69
Australia	−1.66	−1.60	−0.06	3.66
Korea	−4.39	−4.23	−0.16	3.59
New Zealand	−1.60	−1.55	−0.05	3.25
Netherlands	−1.33	−1.29	−0.04	3.00
France	−1.50	−1.46	−0.04	2.65
Germany	−1.52	−1.48	−0.04	2.62
Chile	−1.48	−1.45	−0.04	2.58
Spain	−1.78	−1.74	−0.04	2.28
Singapore	−3.80	−3.72	−0.08	2.18
Italy	−1.91	−1.86	−0.04	2.18
Great Britain	−1.91	−1.87	−0.04	2.05
South Africa/SACU	−2.41	−2.36	−0.04	1.86

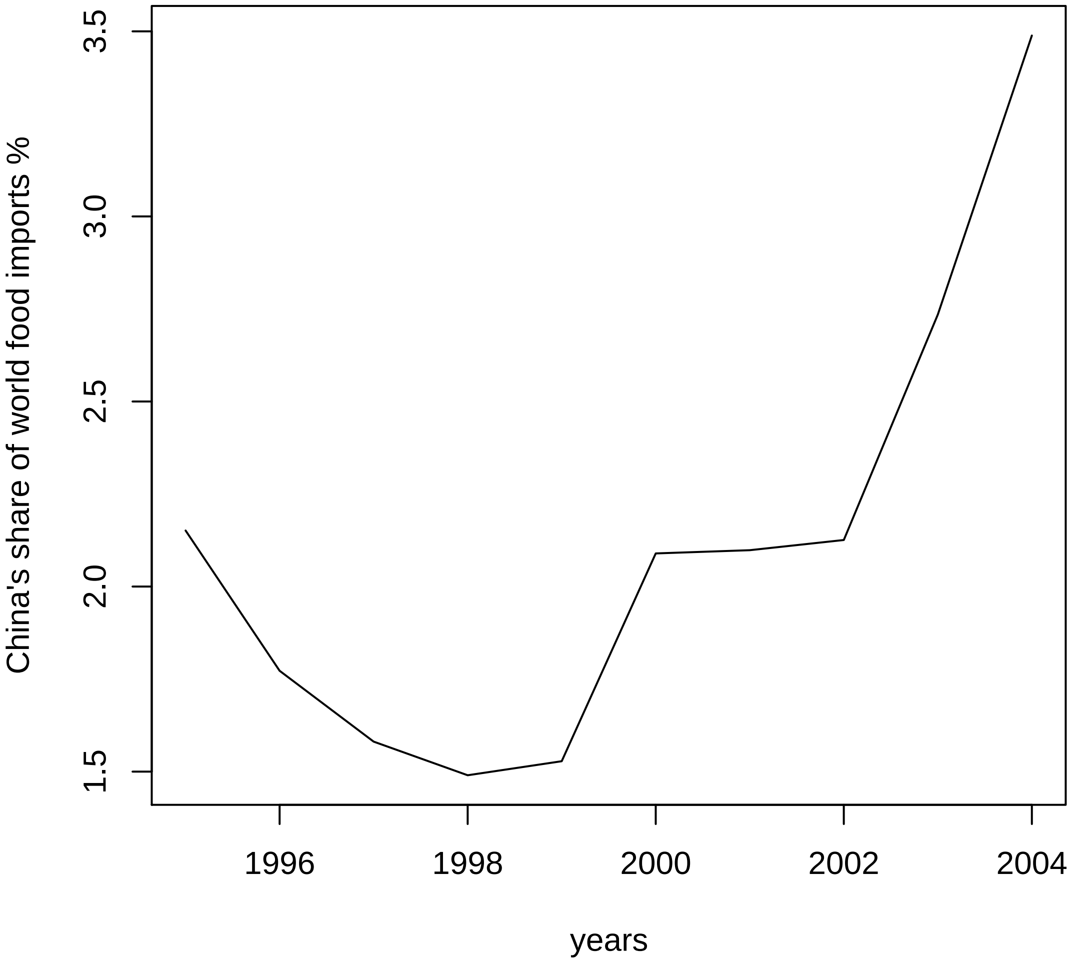
Source: Author's elaboration based on regression output. Notes: The first column is the exporter fixed effects originally obtained from estimating Eq. 8 for year 2006. Next are the exporter fixed effects obtained by minimizing the sum of squared residuals obtained by taking costs, expenditures and outputs as given, and reducing China's expenditures on food to its 1995 levels. Following are columns with the difference between "Before" and "After." The last column expresses this difference as a percentage of the original fixed effects. Because we hold output constant, the increases in these fixed effects reflect larger exports to other countries as China reduces its expenditures on food.

Table 6: Total agricultural exports of selected countries and estimated percentage reduction given a contraction on China's expenditures on food imports.

	Export Value	Direct Effect	Direct + Import Prices Effect
Malawi	356976.28	−0.00	−3.46
Mozambique	225011.20	0.00	−3.59
Tanzania	541595.11	−1.40	−5.15
SACU	4595551.67	−0.45	−4.15
Zambia	156658.23	−0.00	−4.01
Indonesia	9748761.03	−7.37	−10.52
Malaysia	7559254.51	−13.13	−16.58
Argentina	19122031.40	−7.29	−10.48
Brazil	25949264.72	−8.36	−11.26
Peru	3775658.26	−9.65	−12.06

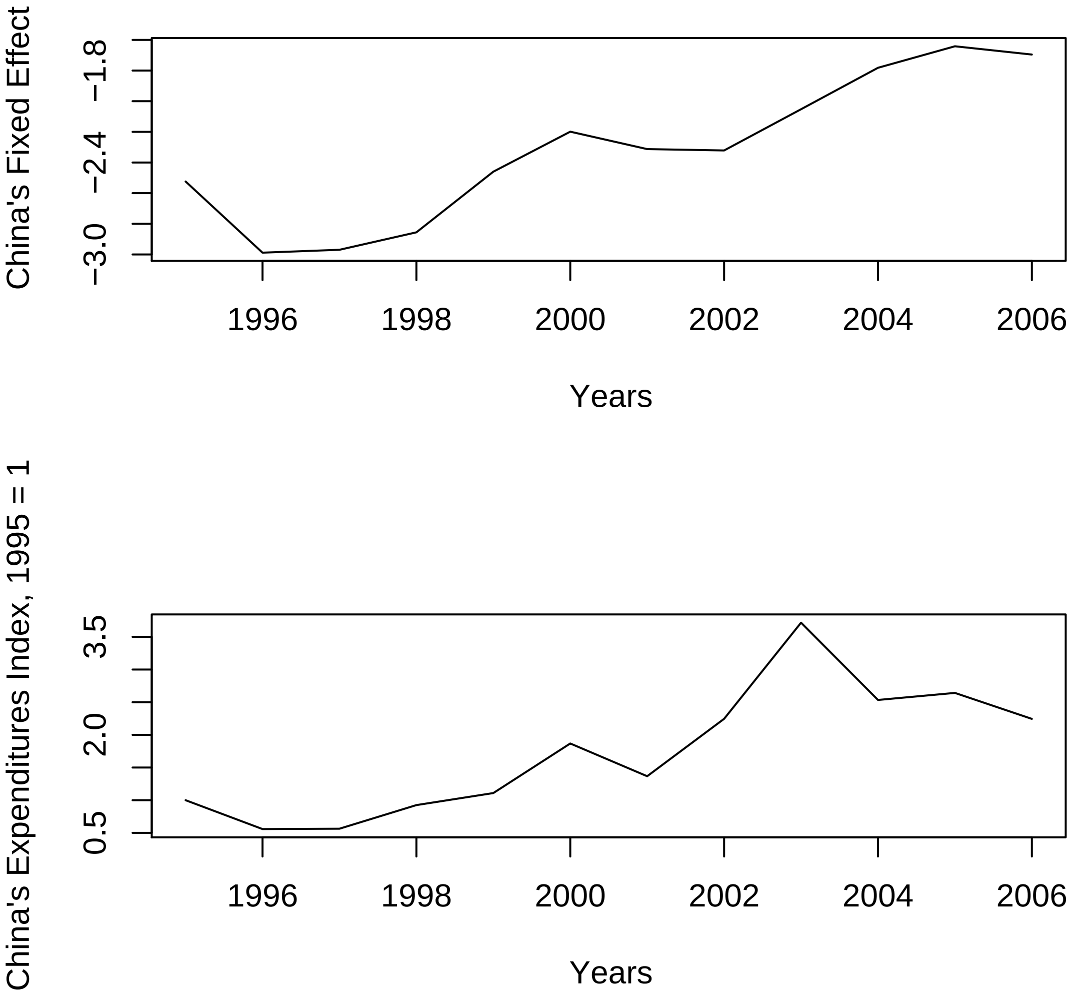
Source: Author's elaboration based on regression output. Notes: The first column is the total agricultural exports in 2006 (US$ thousands). The second column is the percentage by which exports simulated holding China's expenditures constant differ from the observed exports. The third column is the percentage by which exports simulated holding China's expenditures constant and taking into account reductions in the CES import prices differ from the observed exports.

Figure 1: China's share of world agricultural imports.



Source: UN's Comtrade database. Notes: The figure shows the evolution (1995-2004) of the Chinese share of world agricultural imports (in % terms). The agricultural imports are the sum of the first 24 chapters of the Harmonized System. These chapters comprise the bulk of the agricultural products defined in the WTO Uruguay Agreement on Agriculture.

Figure 2: Evolution of China's expenditures on food, estimated from regression fixed effects.



Source: Author's elaboration based on regression output. Notes: The upper panel shows the evolution of China's importer fixed effects ($\hat{\alpha}_j^M$). These are a measure of the percentage by which China's imports differ from US average trade; for example, in 2006 China's imports were $(e^{\hat{\alpha}_j^M} - 1)100 = 81.65\%$ lower than the US average level of trade. The lower panel shows the evolution of China's aggregate expenditures on food inferred from the estimated fixed effects from Eq. 8. To facilitate interpretation, the expenditures are indexed relative to 1995. The procedure to get the expenditures involves: (1) estimating Eq. 8 for each year of the period 1995-2006; (2) using the importers' fixed effects to obtain the importers' price indices using $\widehat{P_j^{1-\sigma_k}} = \sum_i e^{\hat{\alpha}_i^X} \widehat{t_{ij}^{1-\sigma}}$; and (3) using each importer's price index to solve its expenditures, i.e., $\alpha_j^M = \log(E_j/\tilde{P}_j^{1-\sigma}) \Rightarrow E_j = e^{\hat{\alpha}_j^M} \widehat{P_j^{1-\sigma}}$.

Appendices

A Derivation of the gravity equation.

From the text, the exports X from i to j in product class k are given by:

$$X_{ij}^k = \left(\frac{p_i^k t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k \tag{A-1}$$

where σ_k is the elasticity of substitution among origins, p_i^k is the supply price in country i, t_{ij}^k are trade costs such that $t_{ij}^k - 1$ is the ad-valorem tax equivalent of trade costs, E_j^k is the expenditure of j in product k, and P_j^k is the CES price index in the importing country j:

$$P_j^k = \left[\sum_i p_i^k t_{ij}^{k\ 1-\sigma_k}\right]^{1/(1-\sigma_k)}$$

Anderson and van Wincoop (2003, p.175) achieve "general equilibrium determination of prices" by imposing the market clearing condition:

$$Y_i^k = \sum_j X_{ij}^k \quad i \in j \tag{A-2}$$

I.e., in equilibrium, country i's output Y equals the sum of its exports and its own consumption. Anderson and van Wincoop (2003) solve the equilibrium prices p_i^k by first substituting A-1 into A-2:

$$Y_i^k = \sum_j \left(\frac{p_i^k t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k = p_i^{k\ 1-\sigma_k} \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k \tag{A-3}$$

thus obtaining:

$$p_i^k = \left[\frac{Y_i^k}{\sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k}\right]^{\frac{1}{1-\sigma_k}}$$

This equilibrium supply price is substituted back in Expression A-1:

$$X_{ij}^k = \frac{Y_i^k}{\sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k} \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k$$

yielding AvW's gravity equation:

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k}\left(\frac{t_{ij}^k}{P_j^k \Pi_i^k}\right)^{1-\sigma_k}$$

where:

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k}$$

$$(\Pi_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k}$$

B Modification of the system by AVW

The objective is to slightly modify the system of AVW to eliminate the world production term Y^k from the demand function X_{ij}^k and the price terms P_j^k and Π_i^k. This simplifies the identification of China's expenditures $E_{j=China}^k$ and the interpretation of the constant term in the econometric implementation. Start with the system proposed by AVW (Equations 5, 6, and 7 in AVW, p. 708):

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k}\left(\frac{t_{ij}^k}{P_j^k \Pi_i^k}\right)^{1-\sigma_k}$$

subject to:

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k}$$

$$(\Pi_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k}$$

where X_{ij}^k are the exports from i to j in product class k, E_i^k and Y_i^k are the value of production and expenditure in country i for product class k, t_{ij}^k are trade barriers (understood in a broad sense), $\tilde{P}_j^k$ and $\tilde{\Pi}_i^k$ are the CES price indices in countries i and j respectively, and σ_k is the elasticity of substitution among origins.

Rewrite X_{ij}^k with the price indices in explicit form:

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k} \frac{(t_{ij}^k)^{1-\sigma_k}}{\sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k} \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k}}$$

Simplify the Y^k terms:

$$X_{ij}^k = Y^k E_j^k Y_i^k \frac{(t_{ij}^k)^{1-\sigma_k}}{\sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_k} Y_i^k \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} E_j^k}$$

rename the price indices purged of Y_k as $\tilde{\Pi}_i$ and $\tilde{P}_j$, then, rewrite the system as:

$$X_{ij}^k = E_j^k Y_i^k Y^k \left(\frac{t_{ij}^k}{\tilde{\Pi}_i^k \tilde{P}_j^k} \right)^{1-\sigma_k}$$

subject to:

$$(\tilde{P}_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k} \right)^{1-\sigma_k} Y_i^k$$

$$(\tilde{\Pi}_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} E_j^k$$

This is the system of Equations 3, 5, and 4 in the text.