Modeling and Forecasting Agricultural Commodity Support in the Developing Countries

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Modeling and Forecasting Agricultural Commodity Support in the Developing Countries

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Abstract

We use econometric models to study the links between the evolution of agricultural support for six agricultural commodities and economic development as measured by real income per capita. Each commodity has a panel dataset with around 30-50 countries including developed, developing and less developed countries over 1961-2011. We investigate more complicated nonlinear relationships between income and support as measured by Nominal Rates of Assistance (NRAs) than previously examined and employ fixed effects to capture heterogeneity across countries. We find that a significant relationship exists between income measures and measures of border protection, but that the link between income and domestic support is generally weaker. Using these estimates and projections of macroeconomic variables, projections of future agricultural commodity support are generated for Brazil, Russia, India, and China. The projections of economic measures of support are then be compared to the commitments made by these countries to the World Trade Organization (WTO). There is a clear distinction between actual policies in place, aggregate estimates of them (such as NRAs), and WTO notifications. We do not forecast WTO notification data but compare in a general way long-run trends in development and associated support to these countries' multilateral commitments. We use the projections derived from the empirical models to discuss the drivers of agricultural support, how these might have implications for WTO notifications, and how these effects relate to WTO commitments.

1. Introduction

This paper answers the IATRC's call: What's next for agricultural trade policy? The answer to this question depends in part on the evolution of agricultural support in the future. This paper builds on existing, published studies that relate income growth to support by allowing for more complicated relationships and extrapolating support trends into the future. Our results for four key countries demonstrate how continuing long-run trends in economic development can lead to greater support, changes in forms of support, and pressures on trade, trade policy, and trade negotiations. Our empirical work predates the COVID-19 global pandemic and related policy responses, but the overarching policy issues at stake remain just as relevant now as they did prior to the pandemic.

In this analysis we first build econometric models to estimate relationships between agricultural support and economic variables based on a large database, and our models are organized by six commodities with at least 30 countries, including developed and developing countries across geographic regions (Table A1). We focus on six commodities that are widely produced and

consumed, namely wheat, rice, maize, soybean, sugar, and cotton, as representatives of food, feed, and cash crops. Then we use the estimates from these models to focus on four countries, Brazil, China, India and Russia (BRIC), analyzing and projecting their support as measured by Nominal Rates of Assistance (NRAs) to 2035. We then make qualitative comparisons between these projections and recent World Trade Organization (WTO) notifications.

The forecasts of economic measures of support are compared to the commitments made by BRIC countries to the WTO notifications, subject to important limitations. The forecasts are conditional on exogenous macroeconomic assumptions, particularly rising income per person in these countries. Estimates in some cases are weakened by the absence of relevant data, as in the case of soybeans. The comparison of NRAs and WTO support indicators should be viewed as indicators of where there is potential pressure on countries' commitments in qualitative terms; we do not provide any quantitative mapping from NRAs to WTO support indicators. NRAs are an attempt to independently measure the scope of policies that are in place. WTO notifications, however, are reports generated according to the set of rules agreed upon under the WTO and may therefore not reflect actual support in the sector. For example, countries have changed over time the way that they report certain policy tools that they themselves have not changed. One would expect that new policies or increased expenditures would be reflected in notifications but that is not guaranteed.

The results suggest that the increase in agricultural support in the BRIC countries that has in general occurred since 2012, the end of the estimation period due to data constraints, is consistent with the output of the models and can be expected to continue. BRIC wheat support is expected rise – or remain flat in some cases – as these countries develop, with greater border, domestic, and input support. Rice support in these countries is more mixed, but Chinese border support is expected to rise if income growth continues. India border support for cotton is also anticipated to rise. Maize and sugar border support for these countries is projected to remain at current levels or grow, with the exception of Brazil. Non-product specific support forecasts indicate greater support to agriculture in India and Russia in the future, while this form of support is projected to remain approximately unchanged in Brazil and China as these countries grow.

Of course, the exact evolution of policy in these countries will be dependent on more than just economic development but the models can isolate important underlying trends. At a time when some might question the value of existing commitments to constrain border measures and domestic support, a forward-looking assessment informs decisions about future trade discussions about multilateral and bilateral agreements and identify areas of possible future conflict. Given historical relationships, future economic development of BRIC countries would be expected to cause greater support to certain products using certain mechanisms. The potential for existing or new WTO commitments to constrain action should be assessed based on this forward-looking perspective. Anticipated pressure to increase border support for many crops or non-product specific support in a few cases suggests that emphasis by negotiators on these topics might be more appropriate. Setting aside future discussions, the assessment of the value of existing agreements might consider their relevance in light of expectations about how they affect future actions, rather than past behavior.

2. Background

The understanding of the link between support for agriculture and the economic characteristics of a country has evolved rapidly in the last decade. Krueger et al. (1988, 1991) established that developing country policies tended to work against agriculture. This view of the policy context might have dominated the thinking among negotiators as the Uruguay Round Agreement on Agriculture (URAA). Moreover, at that time, developing countries' budget constraints might have been expected to allow little scope for engaging in the sorts of domestic production and export subsidies that were the subject of debate among the United States, European countries, and other developed countries. Speculating, the apparently modest desire among developing countries to provide support and their limited ability to do so might have led to less pressure for trading partners to demand developing countries commit to constraining support. While many developing countries participated in agricultural commodity exports (McCalla, 2001) and negotiated for more access to foreign markets, negotiating positions suggest no greater fervor for liberalizing trade in these goods among this group of countries than any other.

Additional allowances were provided to developing countries in the spirit of economic development. The URAA afforded certain allowances to developing countries, particularly least-developed countries. These included a longer implementation period, smaller tariff and export subsidy reductions, and less constraining domestic support commitments in terms of the amount, both within and beyond the *de minimis*, and exemption of subsidies for purposes of rural development programs, investment, acquiring agricultural inputs, and diversification (Josling et al., 1994). These last allowances for developing countries that are seen to relate to rural and agricultural development were allowed under Article 6.2 of the URAA, and these exemptions are separate from widely accessible green box exclusion for domestic support that is minimally market distorting. As the URAA implementation period came to an end and options for future agreements were assessed, the main problem for provisions relating to development seemed to focus on the definition of countries to which they should apply, although a range of proposals suggest disparate views about the specific allowances (Kennedy et al., 2001). Although not agreed, the concept of special and differential treatment for developing countries was an element of the Doha negotiations, including longer implementation periods, lesser reductions in the upper bounds of support allowed by their URAA commitments, and other allowances intended to support development (Blandford, 2005).

Evidence does not support the view that developing countries no longer tend to tax or impede the agricultural sector. Instead, the "Distortion to Agricultural Incentives" dataset developed by World Bank shows that developing countries often support agriculture since the turn of the century (Anderson and Valenzuela, 2008). Support varies widely among country-commodity combinations, but support has tended to rise over the last decades of the 20th century and this increase can be related to concurrent income growth (Anderson et al., 2013). These findings are reinforced by other estimates of producer and total agricultural policy support. These support estimates also giving evidence to rising domestic support in key developing countries, often tied to area or other inputs, as well as border measures that raise domestic agricultural commodity prices relative to world prices (OECD, 2018). Anecdotal evidence form WTO negotiations suggest that at least some developing countries' positions reflect a priority on maintaining or raising support to domestic agricultural producers.

WTO notification data support the view that support in the developing countries is rising. These data suggest that developing countries make use of the Article 6.2 provisions, their use of domestic support and trade barriers within their agreed limits (including higher *de minimis*), and green box policies. For example, while the sum of notified Aggregate Measure of Support (AMS), de minimis, and blue box support fell in real terms and relative to domestic agricultural production value in the United States and European Union from 2001 to 2013, the sum of these forms of support plus Article 6.2 rose significantly in China and India in absolute and relative terms over the same period (ICTSD, 2017a).

WTO commitments of the BRIC countries imply limits to certain forms of support, but not others. While others such as Brink et al. (2013) provided a more detailed review, these commitments are summarized as follows. China and India domestic support must remain below their *de minimis* levels of 8.5% and 10%, respectively, given the bound rate of zero AMS. Brazil has a *de minimis* limit of 10% as well as some scope for support within its AMS limit if the *de minimis* trigger is exceeded. Russia has a 5% *de minimis* threshold and an AMS allowance as well. Green box and Article 6.2 payments are exempted from such limits for all countries that are eligible to use such measures. Considering domestic support of China and India, for example, China provided rising domestic support from 2008-2010 that was notified as falling below its *de minimis* threshold whereas India notified a total support level under Article 6.2 exemptions that would have been above its *de minimis* limit if notified differently (ICTSD, 2017b). In contrast, Russia notifications indicate that most of its support took the form of non-product-specific subsidies for inputs and credit, insurance, freight, and capital in 2006-2008 (Brink et al., 2013) that one might suspect to be the sort of programs that a developing country might be able to treat as Article 6.2 development assistance and consequently exempt from its commitments.

Evolution of agricultural policies in BRIC countries is critical for understanding world. Nevertheless, setting the forecasts of economic measures of support in comparison to WTO constraints is a means of gauging which limits are more or less likely to become important in the future. By doing so, we encourage economists and decision makers to think about multilateral agreements in terms of how they will affect future policies, if at all, rather than to focus exclusively on past events that might or might not be relevant going forward.

3. Data

3.1 Producer support

The World Bank Agriculture Distortion database is the best available resource upon which to base this research because these data represent agricultural support levels in 75 focus countries from 1955 to 2011 (Anderson and Valenzuela, 2008). Although wonderful, this data source is not perfect: some of these countries have missing data during some time periods and the most recent data are now a decade old. Still, this is the basis of our unbalanced panel dataset, to which we add other relevant information, such as exchange rates and GDP data from World Bank and IMF.

Nominal Rate of Assistance (NRA) is defined as the percentage by which government policies increase (or decrease) gross returns to producers compared with the returns at world prices, adjusted for transportation costs. It is measured in percent/100, so that a value of 1 denotes an increase of 100 percent. If governments raise gross returns to farmers, as can be the case if the

domestic producer price is supported by tariffs or procurement prices, then NRA is positive. A positive NRA might signal other forms of support, such as direct payments tied to outputs or inputs. NRA can be negative if there is an agricultural output tax or an export tax. NRA_O is nominal rate of assistance to output, which includes support provided by both border market price support (NRA_B) and domestic price support (NRA_D). NRA_I is the nominal rate of assistance to inputs, such as fertilizer, seeds and agriculture machinery. Finally, we use two measures of non-product specific support that are adjusted from the original measure provided by the data source. We define NPSR as the non-product-specific support divided by total GDP and NPSRR as the non-product-specific support divided by agricultural GDP, both of which are indicators that can be compared among countries.

The available data vary between the different commodities (see Appendix, Table A1). As in any empirical analysis, the availability of data influences the reliability of the results. In particular, the dataset for soybeans is the least complete, and the results should be interpreted with caution. Given the spirit of the research the soybean results are included here despite their shortcomings. Other commodity estimates are based on datasets that are more complete. In all cases, regression results are based on all data available, not just BRIC data. Our goal is to estimate broad patterns and over ranges of income, subject to country effects, using all available, relevant data. Moreover, the use of all country data is important as a step to forecast BRIC support as a function of income growth. BRIC income growth trends suggest rising per capita income in the long run, which would imply out-of-sample extrapolation if our dataset did not include countries with a wide range of per capita income. In this sense, our analysis is similar to that of Chang et al. (2021), who use a larger sample to forecast energy consumption conditional on income using a nonparametrically semiparametrically specified panel model. We do not at this time forecast all forms of support for all country-commodity combinations, nor compare all these outcomes to WTO notification data, given our focus on evolving BRIC support relative to their commitments.

3.2 Income, population, land area, production, and trade status

Producer support levels through border and domestic market measures for different crops vary significantly among the different countries. We select a group of variables to explain the variations in these producer supports, specifically log real GDP per capita in 2000 USD (INC), agricultural population share (APR), agricultural land area per capita (PAL), and trade status – whether a country was a net importer, net exporter, or net neutral. Based on 2010 data, real GDP per capita in India is only $830, while it is $4699 in Brazil (Table 1). China and India still have large agricultural populations, and agricultural land per capita is only 0.37 hectare and 0.15 hectare, respectively.

China, India and Russia are major wheat producers, and Russia is the largest world wheat exporter (Table 2). China and India are the two largest producers of rice in the world, and these countries also provided substantial domestic price support. Brazil is a major exporter of maize, soybean and sugar. China is a major importer of soybean, sugar, and cotton. Most crop production in India was used for domestic consumption.

3.3 Other variables

We include shift or dummy variables to represent certain anomalies or structural changes that took place during the sample period. We include dummies for three periods of atypical prices, namely 1973-1974, 1986-1988, and 2006-2008. Because these dummies are set to zero in the conditional forecasts, the future values are for normal price conditions or trends rather than any two- or three-year period of atypically high or low prices. A shift variable takes a value of one for the developed countries since 1998 and for the developing countries from 2002. This variable equals zero before those dates. This variable is associated to some extent with the URAA. In reality, the URAA was implemented over a number of years, and these implementation periods differed among countries. Also, there is the risk that other forces caused some effect on support at this time, not the URAA. A negative coefficient on this shift variable might be evidence to support the conclusion that the URAA caused less support but does not constitute proof of this effect given the potential risks.

4. Econometric model

In order to make conditional forecasts of support for many commodities, we estimate a dynamic panel model essentially the same as that which Zhao *et al.* (2018) use to project NRAs for wheat and similar to that used by Anderson and Nelgen (2012) to model NRAs for rice, wheat, maize, soybean, sugar and cotton. Specifically, we use a panel fixed effects approach with country-specific effects and restricted time effects. As in those preceding studies, this approach implicitly recognizes the lessons from political economic theory about the determinants of agricultural policy but does not develop an explicit model of policy makers, voters, or other agents whose optimizations and interactions presumably drive these outcomes, as discussed elsewhere (Anderson et al., 2013; Swinnen, 2009).

The types of NRAs in which we are particularly interested are NRA_B, NRA_D or NRA_I, defined above, for rice, wheat, maize, soybean, sugar and cotton – the same commodities as those examined by Anderson and Nelgen (2012) – as well as NPSR and NPSRR, also defined above. APR is agriculture population share, PAL is per capita agricultural land area, TM and TH are dummy variables of trade status of country i in year t, taking a value of 1 if a net importer (TM) or if no trade (TH), and 0 otherwise, and S is the shift variable defined above that is equal to 1 for the developed countries since 1998 and for the developing countries since 2002 and equal to 0 otherwise.

The dynamic panel model that we utilize may be written as:

$$y_{it} = \alpha + \rho y_{i,t-1} + x_{it}{}' \ \beta + c_t{}' \ \gamma + d_i{}' \ \delta + \varepsilon_{it}, \qquad (1)$$

where y_{it} represents a specific type of assistance. The regressor vector is:

$$x_{it} = \left(INC_{i,t-1}, INC_{i,t-1}^2, INC_{i,t-1}^3, APR_{it}, PAL_{it}, S_{it}, TM_{it}, TH_{it}\right)' \ . \qquad (2)$$

Variables c_t and d_i represent a vector of year indicators and a vector of N-1 binary country indicators respectively, and ε_{it} is an idiosyncratic error term. (The US and 2011 are dropped to

avoid collinearity.) γ ,β ,ρ ,α and δ are parameters to be estimated. We set the coefficients on TM and TH equal to zero in the models with non-product specific measures of assistance.

As Zhao *et al.* (2018) note, time fixed effects are useful to control for influences of all countries' NRAs at given time points. Unless restrictions are imposed, however, it is difficult to forecast time fixed effects. Following those authors, we use fixed effects only to control for periods of
anomalous prices, setting $\gamma_{73} = \gamma_{74}$, $\gamma_{86} = \gamma_{87} = \gamma_{88}$, $\gamma_{06} = \gamma_{07} = \gamma_{08}$, and $\gamma_k = 0$ otherwise. In our forecasts, we set future time effects to be zero. In other words, our forecasts assume no effects from extreme prices in the future, other than those which may be generated endogenously through the lag of the NRA component. We employ least squares to estimate the model, with the expectation that least squares consistently estimates the best linear projection.

5. Empirical results

We test the predictive ability of income and the other covariates on the components of NRA, including NRA_B, NRA_D, and NRA_I. Since our major goal is to forecast the future support level, we only estimate the parameters by OLS. The empirical results are comprised of many regressions: one for each form of NRA across each of the six commodities. Key results are summarized in Table 4-6, with regression results reported in more detail in the appendix (Table A2-Table A8).

5.1. Income's predictive power on support

Income is the main driving force for the projected support. The impact of income on agricultural support varies among commodity-mechanism pairings (Table 4). Results suggest that income per capita has nonlinear impacts on the border market support of wheat, maize, rice and sugar. Results suggest that this association might be less strongly nonlinear for at least some forms of domestic support. The estimated coefficients of the income-support relationship suggest a less pronounced non-linear relationship in terms of changes in the NRA as per capita income rises.

The empirical results indicate whether rising income tends to be associated with more support or less support. The relationship varies by type of support and by crop. Moreover, the initial level of income per capita matters, as well. (Given the nonlinearities detected, the derivative of support with respect to income per capita depends on the level of income per capita.) The effect of an increase in income per capita on support is calculated for various income levels (Table 5).

Wheat support tends to rise with income, but border support rises at an increasing rate initially and then reverses direction. Wheat domestic support, such as direct payments, rises at an increasing rate; for the levels of income shown here, more income correlates with more wheat support and the effect gets larger as a country develops. Input support for wheat increases at all income levels tested and at a rate that drifts slowly upward.

Border support for maize, cotton, and sugar follows a similar pattern as for wheat, with initial income levels associated with more and more market intervention until some turning point is hit and price support tends to be reduced. For rice, there is no stopping as the support is estimated to

continue to rise with income. Soybean border support is estimated over fewer observations and shows a downward trend as income rises some initial level of market intervention.

Domestic support for rice and cotton are like that of wheat: rising faster as income rises. For rice, this pattern is less pronounced, whereas for cotton domestic support rises much quicker at higher income levels tested here. Domestic support for maize and sugar are falling as income rises for all values explored here. Soybean domestic support rises strongly at first but tapers off at some point.

Input support rises with more income for many values and commodities explored here except for rice. For wheat and cotton, the pattern is mildly U-shaped, with an initial decrease in input support at low income levels. In all cases except sugar, input support is increasing at an increasing rate for a middle-income country. Rice input support, the exception, does not seem to be predicted by income.

5.2. Other variables that predict support

Estimated effects of control variables that relate to episodes with atypical prices, the shift variable, and country-specific factors vary, and not all are statistically significant. For example, the shift variable has a negative sign for input, domestic, and border support in almost all cases (Table 6). This result would be consistent with the view that the URAA commitments led to lower agricultural support for most countries, and in any case gives evidence that there was a reduction in support at about the same time that the URAA was implemented after controlling for certain other possible explanations. Details reported in the appendix show that the food price crisis in 1973-74 and 2006-08 also have statistically significant negative signs for border support of wheat, rice, maize, and sugar. In these two instances of surges in international commodity prices, border support was typically reduced, implying smaller domestic price increases than would have occurred during those price surges if the rate of assistance did not change. Agricultural population rate has a negative sign for wheat input support. Trade status has no predictive power for domestic and input support for wheat.

6. Conditional forecasts of agricultural policy support

Overall producer supports for six commodities are projected until 2035 for China, Brazil, India and Russia. These projections are constructed using parameter estimates from Table 4 with restricted time effects and a much larger set of countries. Historical real GDP per capita is as shown in Figure 1, and the income growth assumptions for different countries are from International Monetary Fund (IMF) GDP per capita projections using constant international dollars per person to 2025 with constant growth rates assumed thereafter (Table 7). Other predictors are assumed constant. In other words, the forecasts are conditional on projected income growth but current values of the other covariates – e.g., no changes in future food prices large enough to spur policy intervention. The smooth path of the projections of support are a function of the smooth path of the projections of exogenous variables. In reality the measures of support would exhibit volatility as in the past.

The projected support by crop exhibits a variety of patterns (Figure 2). Under our assumptions, absent a significant increase in global commodity prices, future wheat support in China is predicted by our model to increase over the years of the projections, and this support is mainly driven by

border market price support. Moreover, wheat border support in China is projected to increase the most when compared with other countries. Border market support for wheat in India is also projected to increase with income growth. Input support for wheat in India and border support for wheat in Brazil are also predicted to increase in the coming years. However, these emerging countries are expected to change wheat domestic support very little based on their projected incomes. Wheat producer support in Russia is forecasted to keep at a very low level, and even have a tax by domestic market measures.

Border market support for rice in China and India are expected to increase at similar level in the coming years, while it is predicted to decrease in Brazil due to secular stagnation of economic growth. Moreover, other types of rice producer support in China, India and Brazil are all predicted to be very low and flat.

China, India and Russia are expected to increase border market support for maize, while Brazil is predicted to tax maize producers through border market measures. China is expected to tax maize producers through domestic measures. Russia is likely to support maize production by subsidizing inputs. Since we have limited observations for soybean, and soybean production and exports are highly concentrated in few countries, it is difficult to provide the reliable forecast for soybean producer support in Brazil, China, and India.

China and India are expected to increase their border market support for cotton. India is projected to tax cotton by domestic market measures, and support cotton producers through input subsidies. Border market support for sugar is expected to increase in China, India, and Russia in the projection period, while Brazil has no significant support from border market measures.

Based on income growth, we also predict the ratio of non-product specific support over agricultural GDP in the emerging countries (Figure 3). If this ratio is greater than 10%, it will not be consistent with WTO rule or commitments. Until 2035, the ratios of non-product specific support over agricultural GDP are likely to continue decreasing or stay flat. Non-product specific support in India is predicted to account for 1.7% of agricultural GDP, while this support in Russia, China and Brazil are expected to be around 0.3%, 0.2% and 0.2% of agricultural GDP, respectively. Therefore, non-product specific support in the emerging countries is much smaller than the de minimis ceiling (10%).

All this said, we recognize that there is an important span of time between the end of the historical database and the time at which we write. We provide data drawn from WTO notifications later, some of which help to bridge this gap – although we expect important differences, as emphasized elsewhere. In any case, the main lessons drawn from the broad historical patterns of many countries relate to the policy pressures as their income grows and these effects might not be best measured by a few years of data, even recent ones.

7. Using the results from the model

Having estimated these relationships, how might the results be of use to policy makers and academics? Before going too far we need to be realistic as to what we can extrapolate from the results presented above. As the experience in the U.S. under the Trump administration has shown, there are a highly complex set of issues (many seemingly unrelated to changes in the underlying

economic variables included in the models) that enter into policy decisions with a political and economic environment that is changing all the time. In addition to this, the data set is limited, particularly given that it only includes data to 2012. The objective of the paper is to use quantitative analysis to project agricultural support and then examine possible implications for WTO notifications. A detailed political economic analysis of why this might occur in relation to real life politics is beyond the scope of this paper.

7.1. Limits to the exercise

We do not estimate notification data based on our NRA estimates and we do not forecast notification data as functions of the same control variables that we use to forecast NRAs. Our comparisons are qualitative. Efforts to estimate "shadow notifications" of these countries (Cheng 2008; Gopinath 2008) suggest that the idiosyncrasies of each country must be considered, defying broad approaches. There are consequently many reasons not to attempt quantitative WTO notifications for BRIC countries here.

Conditional forecasts of WTO notification data based on the same controls as we use to forecast NRAs seems impossible. WTO notification data are sparse, starting only after the URAA or accession. The overlap of NRA and WTO notification datasets is limited, particularly for countries like China and Russia that joined after the URAA. Definitions used in notifications can vary, such as in the case of commodity groupings. Shadow notifications and commitments would require more data than we currently have available as, for example, *de minimis* constraints in the future must be based on forecasts of production value, not just NRAs. Moreover, any quantitative exercise of this type might overlook any discretion that countries have in choosing how to classify a program, let alone as regards the exact workings of a program that might be adjusted to shift the corresponding support from one notification category to another. We do not see a way to overcome these limitations to quantitative mappings and rely instead on a more qualitative comparison.

7.2. BRIC notified support and commitments

7.2.1 BRIC support

Under the category of agriculture, Brazil and China submitted 52 and 49 notification reports, respectively. But Russia and India only provided 24 and 17, respectively. Casual assessment of notifications by BRIC countries to the WTO suggest increasing support level. Notification data for China show increasing AMS for most crops, with particularly large increases in support for corn, cotton and soybeans, and growing green box support, although non-product-specific AMS is lower (Table 8). For Brazil, the notification data do not show any clear patterns in green box support or product-specific or non-product-specific AMS, with numbers fluctuating substantially from one year to the next (Table 8).

Notification data for Russia suggest a shift from occasional taxation of specific commodities to support in the most recent data (Table 9). In contrast, the pattern for India notification data shows a strong and positive trend in expenditures on green box support and support that is classified as exempt under the provisions for special and differential treatment (Table 10). Growing support would be consistent with the empirical estimates that growing income tends to cause greater support in certain ranges of income level that seem relevant in the cases of these countries. Going

farther to consider the estimated income effects on different forms of support, WTO notification data also show differences among BRIC countries in terms of how they have committed to constrain their support and how much support they provide.

Brazil is one of the largest agricultural commodity producers, taking a large role in global exports of maize, soybean, and some meat products. Brazil's notifications to the WTO report its support to the sector (WTO, G/AG/N/BRA/52, Feb 2019; WTO, G/AG/N/BRA/48, 2018; WTO, G/AG/N/BRA/48, 2016; WTO, G/AG/N/BRA/41, 2016; WTO, G/AG/N/BRA/40, 2016; WTO, G/AG/N/BRA/37, 2015; WTO, G/AG/N/BRA/32, 2014; WTO, G/AG/N/BRA/30, 2013). More than 70% of spending in Brazil's green box goes to meals for children in public schools. Non-product-specific support in Brazil is mainly debt rescheduling program, insurance program, and production and market credit. Domestic support measures in Brazil reported by the country to the WTO mainly include "product-specific credit," "premium for product outflow," and "agricultural product sale option private premium." Compared to other BRIC countries, Brazil has less support to agricultural producers according to WTO notification data.

Russia provides domestic market support mainly through non-exempt direct payments, such as production subsidies, seeds purchase subsides, with a big share for livestock (WTO, G/AG/N/RUS/24, Sep 2019; WTO, G/AG/N/RUS/21, 2018; WTO, G/AG/N/RUS/13, 2016). A big part of non-product specific AMS goes to interest rate subsidies for short term credits and investment. Most green box support in Russia goes to training, extension and advisory services, and infrastructure services. Russia reported having provided limited and even negative support to major grains in some years. Russia is a key wheat exporter, and policy makers chose to tax or otherwise intervene in wheat exports in some years, such as 2012 and 2015. In 2012, for example, Russia banned grain wheat exports. In 2015, Russia imposed an export tax. Wheat support in Russia after 2011 is highly consistent with our projected support.

India has implemented its minimum support price (MSP) for a variety of crops (Chatterjee and Kapur, 2017). This price-based policy requires a large amount of public money that is notified as "public stockholding for food security purpose" (WTO, G/AG/N/IND/15, March 2019). Public stockholding accounts for more than 80% of total green box spending in recent years, with an average cost of 15 billion dollars per year. An insurance program dominates non-product-specific support in India. This country also provides input subsidies for irrigation, fertilizers and electricity, the average value of which from 2007 to 2017 is 25 billion dollars per year. Taking rice as an example, Indian government procured more and more rice at minimum price from farmers directly at a greater and greater price above the fixed reference price, implying rising support (Table 11). Recent evidence of growing support to crop producers is more generally evident. For example, India first imposed 10% import duty on wheat in March 2017 through notification from the Central Board of Indirect Taxes and Customs of India (Notification No. 50/2017), doubled it to 20% in Nov 2017 (Notification No. 84/2017), raised it to 30% in May 2018 (Notification No. 46/2018), and increased it to 40% in April 2019 (Department of Revenue of India, 2019).

China is a key agricultural product producer and consumer. China's domestic support measures for crops during the period of notification mainly include minimum price support, stock holding, subsidies for improved crop strains and seeds, target price and direct payments. Since 2011, China provided increasing market support for rice and wheat using the minimum procurement

price program, soybean and cotton via a target price policy, and corn and rapeseed primarily through stock holding. Non-product-specific AMS is composed of general subsidies for agricultural production supplies and subsidies to the purchase of agricultural machinery and tools. By way of blue box expenditures, China also provided corn producer subsidies for some years, which were paid based on fixed area and yield.

7.2.2 BRIC WTO commitments

There are three types of support classified under the Uruguay round agreement on agriculture: domestic support, market access and export competition, as summarized elsewhere (Blandford et al., 2010). It seems that WTO disciplines have limited impacts on BRIC domestic support if assessed based on notification data. For example, in China's WTO commitments, each individual product's AMS is 8.5% of value of production at its domestic prices. Based on the notification data, AMS for corn, cotton, and soybean all appear to exceed the 8.5% commitment. In addition, although China's AMS commitment is nil for its accession to WTO, total AMS from 2011-2016 seemed been positive and consequently greater than this constraint (WTO, 2019). Due to limited notification reports and the complications of assessing them, it is extremely difficult to understand whether each country conforms to all of its WTO commitments. For example, according to notification data (Department of Revenue of India, 2019), India's MSP for crops is buttressed by import tariffs.

This also raises the broader point that the fundamental basis of WTO notification data is legal in nature, not economic. Whereas the policy indicators used in our regressions are based on a body of economic literature that studies how to measure the size and even effect of various agricultural policies, WTO notification data and countries commitments are elements of a legal agreement among member countries. The rigorous basis economic science might give for a classification system is hardly the same as negotiated text. Interpretations of the legal text might vary among countries or over time – and should change if a dispute settlement process resolution forces a country to do so.

7.3. BRIC support projections and their WTO commitments

Projected support for Brazil suggests no dramatic increases, but some increases in input or domestic support for certain crops, all from fairly low base levels as compared to many other countries. Arguably, this pattern does not suggest a likelihood that existing commitments are apt to be tested; it seems that broad historical patterns that tend to drive agricultural support are unlikely to generate sharply higher support for these commodities, or non-product-specific support.

China is projected to trend towards greater border support for these crops and more domestic support in most instances, as well. This finding is consistent with the recent WTO panel body finding that China's recent policies have exceeded its commitments (WTO, 2019). Moreover, the projections suggest that further income growth in China will continue to put pressure on its commitments for some time to come.

Domestic, border, and input support of India are all projected to increase in the medium-term future. A commitment to remain within a *de minimis* limit could in principle place limits on some forms of support, although exceptions associated with blue box or Article 6.2 are not constrained. The consequences of growing support by economic measures in the context of constrained and

unconstrainted types of legal categories are unclear. These findings might be used to support the claim that existing agreements are important to constrain some types of support or else to support the claim that the negotiated limits could be defined to more clearly delineate among types of support.

Russia has no agricultural support for several of the studied commodities but is projected to increase support in those instances where it does intervene and to increase existing border support substantially. Border support policies might be addressed under market access and domestic support categories of the WTO. Regarding the former type of commitment, Russian tariffs would presumably be limited by market access commitments, although observers might wonder how this presumption is to be reconciled with the present constraints on imports of some dairy, meat or poultry from certain exporting countries. Domestic support *de minimis* and AMS limits relate to border and other measures, so these commitments might also have an impact in the context of underlying patterns that we find would normally be expected to cause greater support in Russia.

8. Discussion and conclusions

Recent research suggests that agricultural support tends to change as a country's income grows. Here, we build on this literature to estimate these relationships using historical data for a wide range of countries, then extrapolate agricultural support of four key countries in agricultural trade and negotiations, namely Brazil, Russia, India, and China (BRIC countries).

The empirical estimation reveals a complicated relationship between income per person and support for different commodities. The effects of income growth on support is estimated for a range of incomes that represent the current and near-future ranges of BRIC countries. Rising income tends to cause greater border support for wheat, maize, cotton, and sugar initially, but then this effect reverses – an inverted U-shape – whereas rice border support tends to grow with income at an increasing rate. Domestic support for wheat and cotton also increases with income at a rising rate; in most cases, more income means faster increase in domestic support if income grows further. For maize and sugar, domestic support tends to weaken as income grows, whereas there is little predictive power of income for rice domestic support. Apart from the case of rice, input support tends either to take a U-shape or else simply increase with income at all values tested here.

The measures of support used here, NRAs, do not equal WTO notification data nor are they even easily compared to WTO commitments. The findings identify several instances where underlying patterns suggest greater pressure as BRIC countries increase support substantially despite the commitments to constrain such support at some level. While Brazil seems least likely to test its limits, according to these estimates, Russia, India, and China all increase certain types of support for some or several commodities. Border support measures to increase internal prices relative to world prices are most often expected to be expanded or increased in the next ten years. Whether or not these increases in economic measures of support would trigger complaints at the WTO and consequently be subject to some constraints is a question that goes well beyond the scope of our work. The notification of policies is part of a legal process generated from a negotiated multilateral agreement, and accurate assessment might be as much or more a matter of law than of economics. Nevertheless, our findings suggest that existing WTO commitments could come into play either by affecting the design of programs to reduce their most contentious features or perhaps even by constraining the policies chosen, as has arguably happened in China. Finally, the question of

whether or not the WTO matters might also be assessed by noting that the shift variable that is timed to approximate the start of the WTO often has a negative and statistically significant effect on past support.

This analysis uses empirical methods and available data to relate support to income and project agricultural support, then draw inferences with respect to WTO commitments. We do not identify exact causal relationships; estimated parameters do not tell us the forces that cause these relationships to be present. Politics, budgeting constraints, and any number of other factors could play a part, but whatever these factors might be they are assumed to be stable over the period tested here, including the projection period. Additional work could decompose the relationships to test for specific causes. Another improvement would be to exploit any new NRA estimates that update the historical dataset, but there is no update available at this time.

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Tables

Table 1. Summary data representing GDP, population and land showing values in 2010

	GDP per capita (2000 USD)	Agriculture population (million)	Population (million)	Agricultural land (ha/capita)
Brazil	4699	21	195	1.40
China	2423	834	1372	0.37
India	830	592	1225	0.15
Russia	2923	12	143	1.50

Source: World Bank.

Table 2. Summary data representing production and trade status showing values in 2010

	Wheat	Rice	Maize	Soybeans	Sugar	Cotton
	million tons					
Brazil	6 (M)	11 (M)	55 (X)	69 (X)	717 (X)	1 (X)
China	115 (X)	197 (X)	178 (X)	15 (M)	121 (M)	6 (M)
India	81 (H)	144(X)	22 (H)	13 (X)	292 (M)	6 (H)
Russia	42 (X)	1 (n.a.)	3 (X)	1 (n.a.)	22 (M)	n.a. (n.a)

Source: World Bank. Notes: trade status is in the parenthesis. M = net importer, X = net exporter, H = minimal trade

Table 3. Summary of Abbreviations

Abbreviations	Full name
NRA	Nominal Rate of Assistance
NRA_B	Nominal Rate of Assistance by Border Support
NRA_D	Nominal Rate of Assistance by Domestic Support
NRA_I	Nominal Rate of Assistance to Inputs
URAA	Uruguay Round Agreements Act
GDP	Gross domestic product
WTO	World Trade Organization
AMS	Aggregate Measure of Support
NPSR	Non-product-specific support divided by total GDP
NPSRR	Non-product-specific support divided by agricultural GDP
BRIC	Brazil, Russian, India, China
APR	Share of agricultural population
PAL	Per capita agricultural land area
TM, TH	Net import, no trade
INC	Income per capita
S	Shift variable, which is equal to 1 for the developed countries since 1998 and for the developing countries since 2002 and equal to 0 otherwise.

Table 4. Income parameters of different types of support for six commodities

	NRA_B	NRA_D	NRA_I
	Wheat		
INC	-1.669	-0.252	0.167
INC^2	0.243	0.033	-0.022
INC^3	-0.011	-0.001	0.001
	Maize		
INC	-2.714	-0.479	0.142
INC^2	0.398	0.065	-0.018
INC^3	-0.018	-0.003	0.001
	Rice		
INC	1.306	0.018	0.206
INC^2	-0.176	-0.001	-0.026
INC^3	0.008	0.000	0.001
	Cotton		
INC	-0.206	0.337	0.346
INC^2	0.066	-0.063	-0.044
INC^3	-0.004	0.004	0.002
	Soybean		
INC	-0.525	-10.314	-0.070
INC^2	0.077	1.356	0.010
INC^3	-0.004	-0.056	0.000
	Sugar		
INC	-3.08	-0.759	0.110
INC^2	0.439	0.104	-0.014
INC^3	-0.020	-0.005	0.001

Table 5. Estimated impact of changes in income on support depends on the initial level of income (constant dollars)

	Wheat			Rice			Maize		
	Border	Domestic	Input	Border	Domestic	Input	Border	Domestic	Input
Per person income									
250	0.01	0.02	0.02	0.09	0.02	0.01	0.03	-0.04	0.03
500	0.08	0.04	0.01	0.05	0.02	0.00	0.15	-0.02	0.03
1,000	0.11	0.06	0.01	0.02	0.02	-0.01	0.21	-0.01	0.04
10,000	0.01	0.10	0.02	0.10	0.03	-0.02	0.04	-0.05	0.06
20,000	-0.09	0.11	0.03	0.17	0.03	-0.01	-0.13	-0.07	0.08
	Cotton			**Sugar**			**Soybean**		
	Border	Domestic	Input	Border	Domestic	Input	Border	Domestic	Input
Per person income									
250	0.16	0.01	0.04	-0.06	-0.07	0.05	-0.04	-0.46	0.04
500	0.15	0.02	0.03	0.06	-0.05	0.05	-0.03	0.05	0.06
1,000	0.13	0.04	0.02	0.12	-0.04	0.06	-0.03	0.40	0.07
10,000	-0.01	0.19	0.04	-0.08	-0.12	0.11	-0.12	0.41	0.12
20,000	-0.08	0.27	0.06	-0.27	-0.17	0.13	-0.18	0.07	0.13

Source: first derivatives of support with respect to income estimated by authors.

Table 6. Coefficients of proxy variable for URAA or WTO membership

	NRA_B	NRA_D	NRA_I
Wheat	-0.037	-0.025	-0.008
Maize	-0.008	-0.005	-0.006
Rice	-0.092	-0.008	-0.003
Cotton	0.076	0.010	-0.008
Soybean	-0.021	-0.040	-0.002
Sugar	0.096	-0.009	-0.005

Source: estimated by authors.

Table 7. GDP per capita growth rate in Brazil, China, India, and Russia

	2010	11	12	13	14	15	16	17	18	19	20	21		25	
China	10.0	9.0	7.4	7.3	6.7	6.4	6.2	6.4	6.3	5.8	0.9	8.9	…	5.7	…
Brazil	6.5	3.1	1.0	2.1	-0.3	-4.4	-4.1	0.5	0.5	0.3	-5.9	2.2	…	2.0	…
India	8.7	5.2	4.1	5.0	6.0	6.6	6.9	5.7	4.7	2.9	0.5	6.0	…	8.2	…
Russia	4.4	5.0	3.5	1.5	-1.1	-2.1	0.1	1.7	2.6	1.4	-5.4	3.6	…	1.5	…

Source: IMF. GDP is expressed in constant international dollars per person. Data are derived by dividing constant price purchasing-power parity (PPP) GDP by total population. Data through 2019 are historical. Data for 2020 and are IMF projections as of April 2020. Data after 2021 are scenario data based on linear interpolations to a steady-state 2025 growth rate based on pre-pandemic IMF projections and then constant growth rates thereafter.

Table 8. Aggregated market support and grand total green box in China and Brazil

China	Corn	Cotton	Rice	Soybean	Sugar	Wheat	NPS	Green	NPS AMS
	(AMS relative to total production value)							*(billion yuan)*	
2002	0.0%	2.3%	0.0%	0.2%	0.0%	0.0%	0.0%	252	2514
2003	0.0%	1.3%	0.0%	0.6%	0.0%	0.0%	0.1%	258	2646
2004	0.1%	1.1%	0.9%	0.2%	0.0%	0.1%	0.1%	308	3254
2005	0.1%	1.3%	-4.0%	0.2%	0.0%	0.7%	0.1%	310	3543
2006	0.2%	0.9%	-3.1%	0.2%	0.0%	-6.6%	0.4%	357	3684
2007	0.2%	3.3%	1.1%	0.2%	0.0%	-4.0%	0.7%	458	4444
2008	0.8%	2.5%	1.5%	0.7%	0.0%	-3.3%	1.5%	593	5280
2009	2.3%	4.6%	0.4%	1.7%	0.0%	2.0%	1.6%	477	5473
2010	2.0%	1.9%	1.7%	1.6%	0.0%	2.5%	1.6%	535	6290
2011	2.0%	12.0%	1.5%	5.5%	6.1%	2.0%	1.4%	565	104
2012	2.1%	27.5%	1.9%	9.0%	9.5%	4.9%	1.6%	687	132
2013	10.9%	28.4%	6.9%	4.3%	0.0%	3.3%	1.5%	766	133
2014	15.7%	23.8%	6.1%	12.6%	0.0%	7.3%	1.5%	836	135
2015	25.0%	29.3%	6.3%	12.2%	0.0%	6.1%	1.4%	1083	134
2016	13.2%	21.3%	4.4%	13.8%	0.0%	6.5%	0.3%	1313	26
Brazil	Corn	Cotton	Rice	Soybean	Sugar	Wheat	NPS	Green	NPS AMS
	(AMS relative to total production value)							*(billion USD)*	
2004	1.8%	1.6%	0.8%	0.6%	0.5%	7.6%	1.6%	0.0	0.9
2005	0.4%	0.0%	0.1%	0.0%	0.2%	20.2%	2.3%	1.9	1.2
2006	2.8%	0.0%	2.9%	0.2%	0.0%	4.9%	2.3%	2.4	1.3
2007	1.3%	16.7%	3.2%	1.3%	0.0%	0.0%	2.0%	2.3	1.5
2010	3.4%	11.5%	3.6%	0.0%	0.2%	5.3%	2.5%	4.9	2.5
2013	0.0%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	6.2	2.1
2014	1.8%	0.0%	0.0%	0.0%	0.2%	2.6%	1.2%	4.3	2.3
2015	0.7%	1.9%	0.0%	0.0%	0.1%	0.0%	1.2%	1.6	1.7
2016	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%	1.4%	2.0	2.1
2017	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	1.2%	1.7	1.9

Sources: WTO notifications.

Table 9. Aggregated market support and grand total green box in Russia

Russia	Corn	Cotton	Rice	Sugar	Wheat	Green	NPS AMS
	(AMS relative to total production value)					*(billion USD)*	
2012	0.0%	0.0%	0.0%	0.0%	negative	1.7	5.7
2013	0.0%	0.0%	0.0%	0.0%	0.0%	2.9	5.5
2014	0.0%	0.0%	0.0%	0.0%	0.0%		
2015	0.0%	0.0%	0.0%	0.0%	negative		
2016	0.0%	0.0%	0.4%	0.0%	0.0%	1.8	2.4
2017	0.0%	700.0%	1.9%	0.0%	0.2%	2.2	2.8

Sources: WTO notifications.

Table 10. Aggregated market support and grand total green box in India

India	Green box	Spec. Differential treatment
	(billion USD)	
2002	5	7
2003	6	9
2004	6	11
2005	6	12
2006	6	16
2007	10	22
2008	17	31
2009	17	30
2010	25	32
2011	19	25
2012	19	24
2013	18	23
2014	21	25
2015	18	24
2016	19	23
2017	31	23

Sources: WTO notifications.

Table 11. Market price support for rice in India

	Applied administer price	External reference price	Eligible production	Total price support	Total production
	usd/ton	usd/ton	million tons	million usd	tons
2004/05	187	262.51	24.68	-1864	125
2005/06	193.13	262.51	27.66	-1919	138
2006/07	205.92	262.51	25.11	-1421	139
2007/08	277.57	262.51	28.74	433	145
2008/09	293.54	262.51	34.1	1058	148
2009/10	316.32	262.51	32.03	1724	136
2010/11	329.24	262.51	34.2	2282	144
2011/12	338.06	262.51	35.04	2647	158
2012/13	344.67	262.51	34.04	2797	158
2013/14	324.79	262.51	31.85	1984	159
2014/15	333.66	262.51	32.04	2280	157
2015/16	323.06	262.51	33.54	2031	157
2016/17	328.75	262.51	38.11	2524	159
2017/18	360.72	262.51	38.13	3745	169

Sources: WTO notifications and FAO (production data).

Table 12. WTO commitments of BRIC countries

	Brazil	Russia	India	China
de minimis (%)	10	5	10	8.5
Final bound rate (%)	55	10.8		15.7
Bound Total AMS (1 million dollar)	912.105	5400	0	0
BLUE Box (Overall cap)				5%

Notes: OTDS represents overall trade-distorting domestic support.

Figures

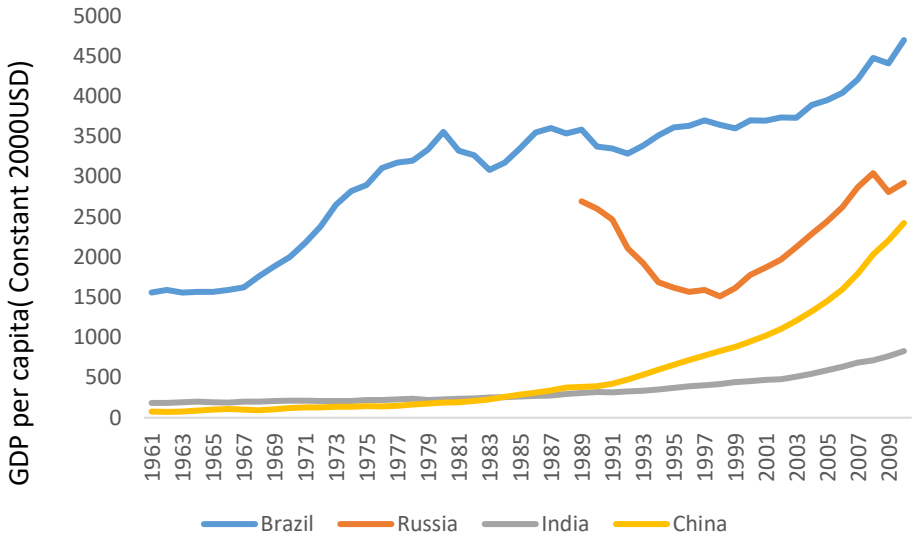


Figure 1. Historic GDP per capita in BRIC countries.
Source: World Bank.

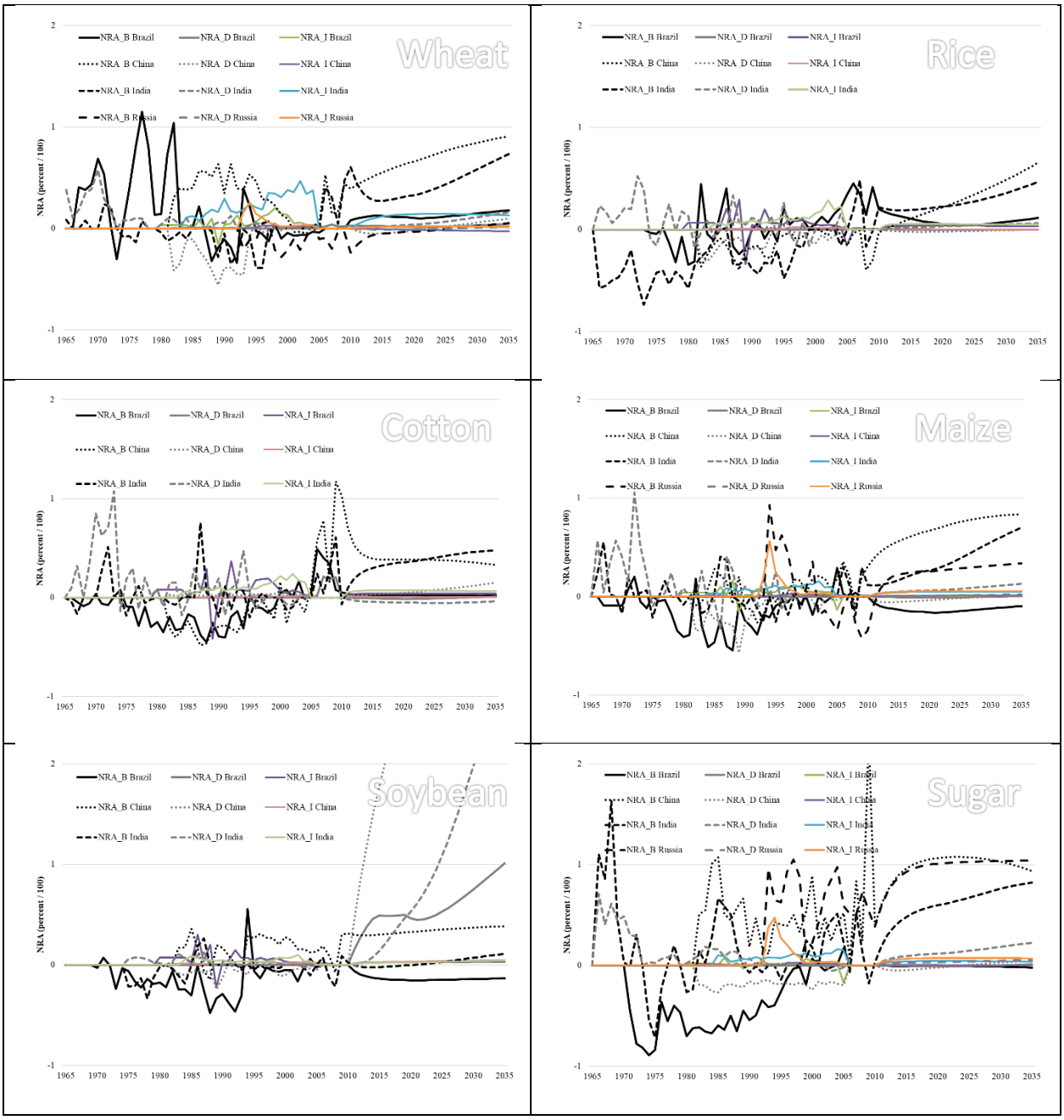


Figure 2. Conditional forecasts of producer support to 2035.
Source: World Bank historical data (Anderson and Valenzuela, 2008; Anderson and Nelgen, 2013) and forecasts by the authors.

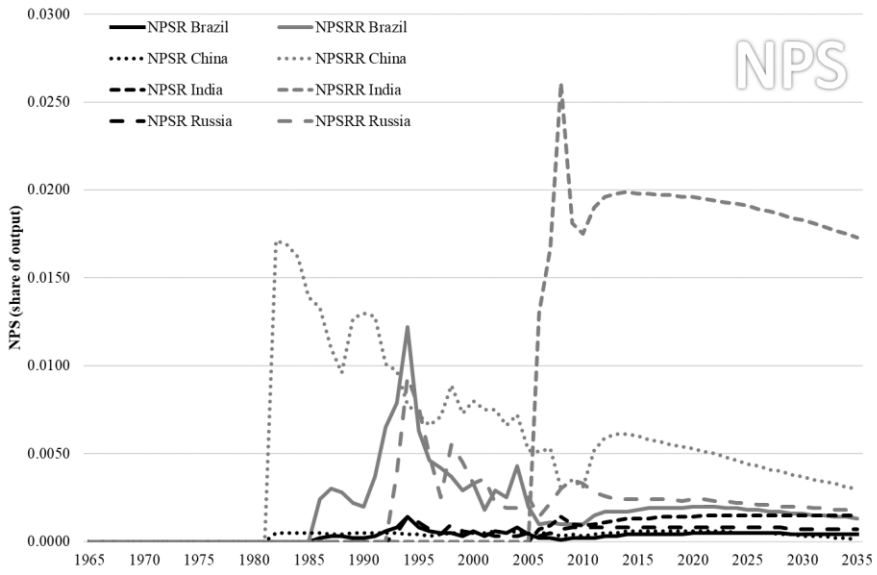


Figure 3. Conditional forecasts of non-product specific support to 2035.

Notes: NPSR as the non-product-specific support divided by total GDP and NPSRR is the ratio of non-product specific support over agricultural GDP.

Source: World Bank for historical data (Anderson and Valenzuela, 2008; Anderson and Nelgen, 2013) and forecasts by the authors.

Appendix

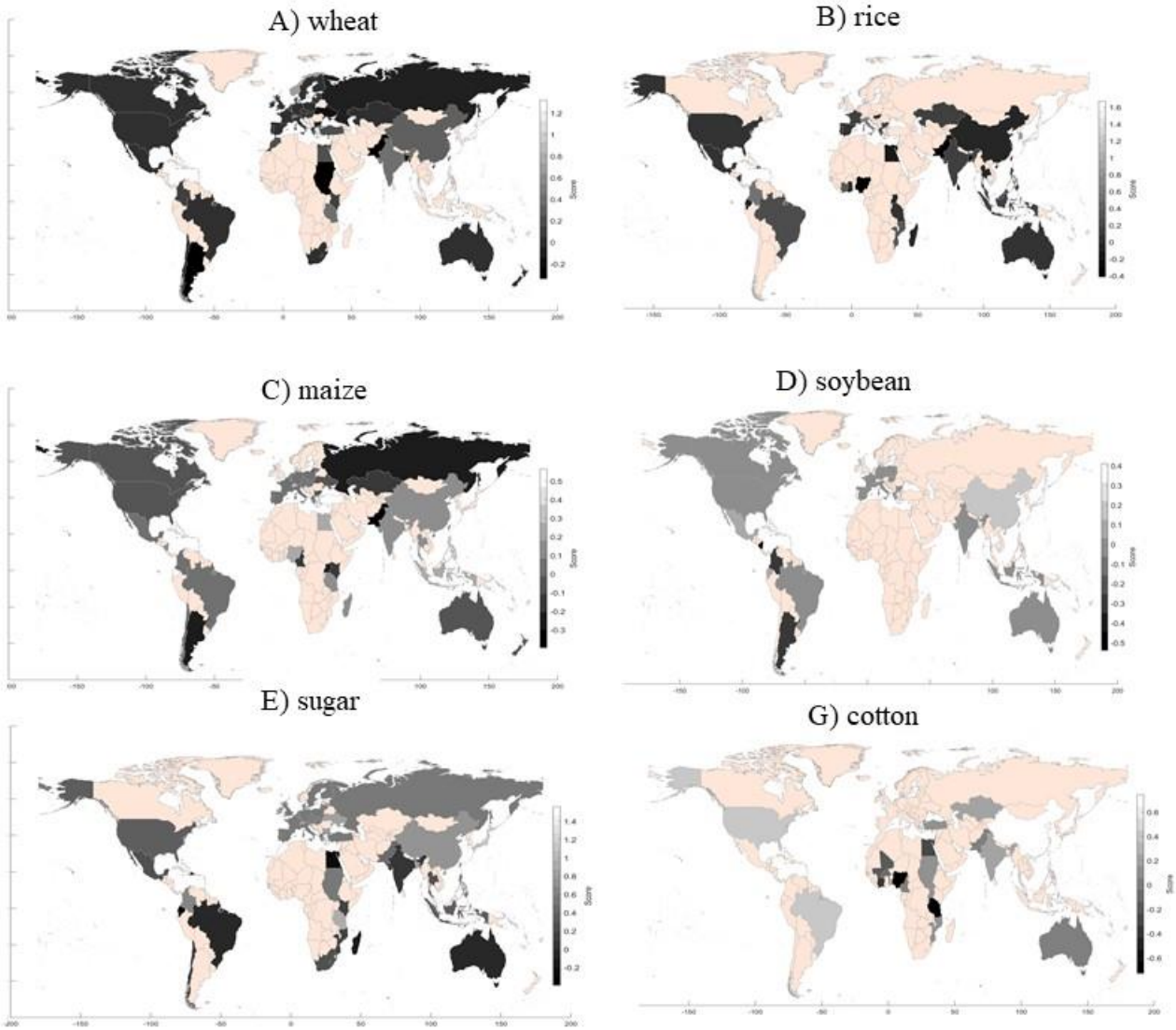
A.1. Data

Table A1. Countries included in each regression (continued on next page)

Wheat	Rice	Maize	Soybean	Sugar	Cotton
Argentina	Australia	Argentina	Argentina	Australia	Australia
Australia	Bel-Lux	Australia	Australia	Austria	Benin
Austria	Bangladesh	Austria	Bel-Lux	Bel-Lux	Burkina Faso
Bel-Lux	Bulgaria	Bel-Lux	Bulgaria	Bangladesh	Brazil
Bangladesh	Brazil	Bulgaria	Brazil	Bulgaria	China
Bulgaria	China	Brazil	Canada	Brazil	Cote d'Ivoire
Brazil	Cote d'Ivoire	Canada	China	Canada	Cameroon
Canada	Colombia	Switzerland	Colombia	Switzerland	Colombia
Switzerland	Dominican Republic	Chile	Czech rep	Chile	Egypt
Chile	Ecuador	China	Germany	China	India
China	Egypt	Cameroon	Ecuador	Colombia	Israel
Colombia	Spain	Colombia	Spain	Czech rep	Kazakhstan
Cyprus	France	Czech rep	France	Germany	Mali
Czech rep	Ghana	Germany	Greece	Denmark	Mozambique
Germany	Greece	Ecuador	Hungary	Dominican Republic	Nigeria
Denmark	Hungary	Egypt	Indonesia	Ecuador	Pakistan
Egypt	Indonesia	Spain	India	Egypt	Sudan
Spain	India	Ethiopia	Italy	Spain	Senegal
Estonia	Italy	France	Japan	Finland	Chad
Ethiopia	Japan	Ghana	Korea	France	Togo
Finland	Kazakhstan	Greece	Morocco	UK	Turkey
France	Korea	Hungary	Mexico	Greece	Tanzania
UK	Sri Lanka	Indonesia	Nicaragua	Hungary	Uganda
Greece	Morocco	India	Poland	Indonesia	US
Hungary	Madagascar	Italy	Romania	India	Zambia
India	Mexico	Kazakhstan	Slovakia	Ireland	Zimbabwe
Ireland	Mozambique	Kenya	Thailand	Italy	
Israel	Malaysia	Lithuania	US	Japan	
Italy	Nigeria	Morocco	Zambia	Kenya	
Japan	Nicaragua	Madagascar	Zimbabwe	Lithuania	
Kazakhstan	Pakistan	Mexico		Latvia	
Kenya	Philippines	Nigeria		Morocco	
Korea	Portugal	Nicaragua		Madagascar	
Lithuania	Romania	Netherlands		Mexico	
Latvia	Senegal	New Zealand		Mozambique	
Malta	Thailand	Pakistan		Nicaragua	
Morocco	Turkey	Philippines		Netherlands	
Mexico					

Wheat	Rice	Maize	Soybean	Sugar	Cotton
Netherlands	Taiwan	Poland		Pakistan	
Norway	Tanzania	Portugal		Philippines	
New Zealand	Uganda	Romania		Poland	
Pakistan	US	Russia		Portugal	
Poland	Vietnam	Slovakia		Romania	
Portugal	Zambia	Slovenia		Russia	
Romania		Thailand		Sudan	
Russia		Turkey		Slovakia	
Sudan		Tanzania		Slovenia	
Slovakia		Uganda		Sweden	
Slovenia		Ukraine		Thailand	
Sweden		US		Turkey	
Turkey		Zambia		Tanzania	
Taiwan		Zimbabwe		Uganda	
Tanzania				Ukraine	
Ukraine				US	
US				Vietnam	
RSA				RSA	
Zambia					
Zimbabwe					

Figure A1. Graphical representation of countries included in the estimation



Note. The NRAs for each commodity are summarized in these panels: pink indicates no data are available, black indicating a small amount of support (positive or negative) or no support; and lighter gray colors corresponding to a higher NRA.

A.2. Empirical results

We have 2609 observations for the wheat regression, which includes 58 countries. Wheat border market support is highly related to the real income per capita. The coefficient of income, income square and income cubic are all statistically significant at the 5% level. WTO membership has significantly negative impact on the border market support, which means WTO restricts the use of tariffs or other protection measures. The international food price spikes in 1972-74 and 2006-08 have negative impacts on border market support, while the food price slumps in 1986-88 has positive effect on border market support. Importing countries and non-trade countries both tend to increase wheat domestic market price through border market support. On the contrary, domestic market support has no significant relationship with income level.

Table A2. Regression results for NRA_B, NRA_D and NRA_I of wheat

Variables	NRA_B	NRA_D	NRA_I
NRA_lag	0.594	0.662	0.736
	(0.044)***	(0.086)***	(0.073)***
INC_lag	-1.669	-0.252	0.167
	(0.797)**	(0.594)	(0.089)*
INC_lag^2	0.243	0.033	-0.022
	(0.108)**	(0.083)	(0.011)*
INC_lag^3	-0.011	-0.001	0.001
	(0.005)**	(0.004)	(0.000)**
APR	0.175	-0.055	-0.029
	(0.143)	(0.051)	(0.014)**
PAL	0.000	0.002	0.000
	(0.003)	(0.002)	(0.000)
S	-0.037	-0.025	-0.008
	(0.019)*	(0.009)***	(0.003)**
73-74	-0.281	-0.028	0.005
	(0.029)***	(0.014)**	(0.004)
86-88	0.257	-0.014	0.004
	(0.047)***	(0.031)	(0.002)
06-08	-0.089	0.011	-0.001
	(0.024)***	(0.026)	(0.002)
TM	0.070	0.019	-0.001
	(0.027)***	(0.018)	(0.002)
TH	0.114	-0.039	0.023
	(0.050)**	(0.029)	(0.017)
Const	3.219	0.436	-0.411
	(1.893)*	(1.351)	(0.231)*
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	2609	2609	2609

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We cover 51 countries in the maize regression model. Income per capita has a statistically significant impact on maize border market support, domestic market support and input support. The impacts of income on maize border market support is much bigger than that on domestic market and input support. The parameter signs of different income terms are consistent for border market and domestic market support. Countries with higher agricultural population rates are more likely to support maize production through both border and domestic market support. In addition, agricultural land area per capita also has a statistically significant effect on border market support. WTO accession has no impacts on maize border and domestic market support, but negatively affects the maize input support. The international food price crises have statistically significant impacts on border market support. Most surprisingly, trade status has no statistically significant effect on maize producer support at all.

Table A3. Regression results for NRA_B, NRA_D and NRA_I of maize

	NRA_B	NRA_D	NRA_I
NRA_lag	0.544	0.455	0.614
	(0.046)***	(0.084)***	(0.100)***
INC_lag	-2.714	-0.479	0.142
	(0.697)***	(0.276)*	(0.068)**
INC_lag^2	0.398	0.065	-0.018
	(0.092)***	(0.035)*	(0.009)**
INC_lag^3	-0.018	-0.003	0.001
	(0.004)***	(0.002)*	(0.000)**
APR	0.430	0.049	-0.001
	(0.192)**	(0.024)**	(0.009)
PAL	-0.006	0.001	0.000
	(0.002)***	(0.001)	(0.000)
S	-0.008	-0.005	-0.006
	(0.019)	(0.005)	(0.003)**
73-74	-0.230	-0.005	0.005
	(0.035)***	(0.004)	(0.004)
86-88	0.195	0.008	0.003
	(0.052)***	(0.011)	(0.002)
06-08	-0.076	0.000	-0.001
	(0.021)***	(0.004)	(0.002)
TM	-0.023	0.010	0.005
	(0.030)	(0.008)	(0.003)
TH	-0.045	-0.046	0.002
	(0.038)	(0.031)	(0.003)
Const	5.520	1.044	-0.388
	(1.682)***	(0.696)	(0.169)**
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	2320	2320	2320

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We include 44 countries in rice regression model. Income terms are not significantly related with rice border and domestic market support, but have statistically significant effects on rice input support. These means that most countries might prefer to support rice producers from input side. Countries with higher agricultural population rate have smaller border market support to rice. WTO accession restricts the use of border market support and input support to rice. The food price spike in 1973-74 has significantly negative effect on rice border and domestic market support. The food price spike in 2006-08 has negative impact on only border market support for rice. Countries that do not trade at all tend to have smaller border market support than other countries. Countries that import and do not trade provide assistance to rice producers by domestic market support and input support.

Table A4. Regression results for NRA_B, NRA_D and NRA_I of rice

	NRA_B	NRA_D	NRA_I
NRA_lag	0.798	0.738	0.270
	(0.029)***	(0.082)***	(0.197)
INC_lag	1.306	0.018	0.206
	(0.986)	(0.222)	(0.072)***
INC_lag^2	-0.176	-0.001	-0.026
	(0.133)	(0.030)	(0.009)***
INC_lag^3	0.008	0.000	0.001
	(0.006)	(0.001)	(0.000)***
APR	-0.257	-0.013	-0.020
	(0.149)*	(0.022)	(0.008)**
PAL	0.004	0.000	0.000
	(0.003)	(0.001)	(0.000)
S	-0.092	-0.008	-0.003
	(0.024)***	(0.006)	(0.002)*
73-74	-0.311	-0.025	0.002
	(0.048)***	(0.011)**	(0.002)
86-88	0.027	0.009	0.004
	(0.051)	(0.016)	(0.003)
06-08	-0.127	-0.007	-0.003
	(0.037)***	(0.005)	(0.002)
TM	-0.043	0.010	0.007
	(0.039)	(0.006)*	(0.003)**
TH	-0.126	0.053	0.028
	(0.054)***	(0.029)*	(0.015)*
Const	-3.636	-0.080	-0.523
	(2.326)	(0.530)	(0.184)***
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	2071	2071	2071

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We cover 26 countries for cotton regression model. As with rice, income has no significant impacts on cotton border and domestic market support, but has statistically a significant impact on cotton input support. Countries with a higher agricultural population share could support less to cotton producers from input side. Countries with higher agricultural land per capita could support more to cotton producers through both border and domestic market support. WTO accession has positive effect on cotton border market support, but negative effect on cotton input support. Cotton importing countries protect cotton producers more through domestic market support.

Table A5. Regression results for NRA_B, NRA_D and NRA_I of cotton

	NRA_B	NRA_D	NRA_I
NRA_lag	0.508	0.467	0.277
	(0.056)***	(0.123)**	(0.190)
INC_lag	-0.206	0.337	0.346
	(0.982)	(0.520)	(0.126)***
INC_lag^2	0.066	-0.063	-0.044
	(0.135)	(0.072)	(0.016)***
INC_lag^3	-0.004	0.004	0.002
	(0.006)	(0.003)	(0001)**
APR	0.058	0.055	-0.035
	(0.107)	(0.031)*	(0.009)***
PAL	0.012	0.005	0.000
	(0.007)*	(0.003)**	(0.000)
S	0.076	0.010	-0.008
	(0.024)***	(0.008)	(0.003)***
73-74	-0.042	-0.001	0.002
	(0.53)	(0.028)	(0.004)
86-88	-0.019	0.010	0.006
	(0.027)	(0.010)	(0.004)
06-08	0.006	0.025	-0.006
	(0.043)	(0.020)	(0.003)**
TM	0.011	0.077	0.013
	(0.029)	(0.024)***	(0.011)
TH	-0.077	-0.043	0.013
	(0.062)	(0.054)	(0.019)
Const	-0.191	-0.651	-0.892
	(2.266)	(1.252)	(0.308)***
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	1365	1365	1365

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We have 30 countries in the soybean regression model. Income, income squared and income cubed are statistically significant for soybean domestic support, and have no significant effect on border market support and input support. The food price slump in 1986-88 has significant negative impacts on border market support. The food price spike in 2006-08 is negatively related to soybean domestic market support.

Table A6. Regression results for NRA_B, NRA_D and NRA_I of soybean

	NRA_B	NRA_D	NRA_I
NRA_lag	0.588	0.765	0.392
	(0.088)***	(0.061)***	(0.155)**
INC_lag	-0.525	-10.314	-0.070
	(0.979)	(3.085)***	(0.073)
INC_lag^2	0.077	1.356	0.010
	(0.129)	(0.401)***	(0.010)
INC_lag^3	-0.004	-0.056	0.000
	(0.005)	(0.016)***	(0.000)
APR	0.145	0.321	0.036
	(0.200)	(0.274)	(0.023)
PAL	-0.002	0.009	0.000
	(0.002)	(0.007)	(0.000)
S	-0.021	-0.040	-0.002
	(0.021)	(0.050)	(0.002)
73-74	-0.078	-0.004	-0.001
	(0.048)	(0.028)	(0.003)
86-88	-0.080	0.089	0.010
	(0.032)**	(0.083)	(0.006)
06-08	-0.026	-0.089	-0.002
	(0.016)	(0.050)*	(0.001)
TM	0.009	-0.018	0.004
	(0.037)	(0.021)	(0.004)
TH	0.023	-0.048	0.014
	(0.031)	(0.038)	(0.014)
Const	1.026	23.330	0.113
	(2.246)	(6.951)***	(0.166)
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	1216	1216	1216

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We have 56 countries in the sugar regression model. All income variables are statistically significant for sugar border and domestic market support, but have no significant impacts on sugar input support. Countries with higher agricultural population rates and smaller agricultural land per capita could support sugar producers more by domestic market support. Border market support for sugar in countries with WTO accession is higher than those that did not join the WTO. The international food price spikes in 1973-74 and 2006-08 have significantly negative impacts on sugar border and domestic market support. Countries that do not trade sugar may tax the producers by domestic measures, and support sugar production through input support.

Table A7. Regression results for NRA_I, NRA_B and NRA_D of sugar

	NRA_B	NRA_D	NRA_I
NRA_lag	0.678	0.577	0.604
	(0.034)***	(0.201)***	(0.120)***
INC_lag	-3.080	-0.759	0.110
	(1.587)*	(0.411)*	(0.090)
INC_lag^2	0.439	0.104	-0.014
	(0.211)**	(0.055)*	(0.012)
INC_lag^3	-0.020	-0.005	0.001
	(0.009)**	(0.002)*	(0.001)
APR	0.127	0.071	-0.014
	(0.299)	(0.041)*	(0.013)
PAL	-0.005	-0.001	0.000
	(0.005)	(0.001)**	(0.000)
S	0.096	-0.009	-0.005
	(0.037)***	(0.006)	(0.003)
73-74	-0.571	-0.012	0.004
	(0.065)***	(0.005)**	(0.003)*
86-88	0.043	-0.025	0.001
	(0.061)	(0.024)	(0.001)
06-08	-0.255	-0.002	-0.002
	(0.058)***	(0.007)	(0.002)
TM	0.063	0.006	0.007
	(0.056)	(0.007)	(0.004)*
TH	0.006	-0.043	0.016
	(0.063)	(0.018)**	(0.007)**
Const	7.486	1.697	-0.285
	(3.751)**	(0.960)*	(0.219)
Time FE	No	No	No
Country FE	Yes	Yes	Yes
Obs	2579	2579	2579

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.

We also estimate the relationship between non-product specific support and income, agricultural population rate, per capita agricultural land, shift for WTO membership, and dummies for food spikes or slumps. We use the ratios of non-product specific support over agricultural GDP and total GDP as dependent variables. Both ratios are significantly related to lagged ratios, and agricultural population ratio. The higher the agricultural population ratio, the more non-product specific support is provided. In addition, the shift variable for WTO accession has a negative impact on the ratio of non-product specific support accounting for agriculture GDP.

Table A8. Regression results for non-product specific support

	NPS/GDP	NPS/ag GDP
NRA_lag	0.775	0.405
	(0.148)***	(0.208)*
INC_lag	-0.0012	0.0222
	(0.001)	(0.0196)
INC_lag^2	0.0002	-0.0028
	(0.0002)	(0.002)
INC_lag^3	0.0000	0.0001
	(0.0000)	(0.0001)
APR	0.0003	0.004
	(0.0001)**	(0.002)**
PAL	0.000	0.000
	(0.000)	(0.00)
S	0.000	-0.0005
	(0.000)	(0.0002)**
73-74	0.000	-0.0004
	(0.000)	(0.0005)
86-88	0.000	-0.0001
	(0.000)	(-0.0001)
06-08	0.000	-0.0003
	(0.000)	(0.0004)
Const	0.0028	-0.0520
	(0.0031)	(0.053)
Time FE	No	No
Country FE	Yes	Yes
Obs	4276	4276

Note: *** denotes significance at the 1% level, ** denotes significance at the 5% level, * denotes significance at 10% level. Income is GDP per capita is in constant 2000 US dollars. APR and PAL are agriculture population share and per capita agricultural land area. TM and TH are one for net importer and one for neither net importer nor net exporter, respectively, and zero otherwise. Variables 1973-74, 1986-88, and 2006-08 are time indicators set to be equal over each of those periods and zero otherwise.

Source: Estimated by the authors.