The Impacts of Export Taxes on Agricultural Trade

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Abstract: Most major types of trade barriers on agricultural products have been reduced since the formation of the World Trade Organization. Globally, tariffs have decreased significantly, export subsidies are scheduled to be eliminated, and the Trade Facilitation Agreement holds some promise on addressing non-tariff measures. However, export restrictions – mainly export taxes – have remained prolific and in fact, their number has increased over the last ten years. Perhaps because they are only used by a subset of countries or on some commodities, export taxes have not received the same scrutiny in multilateral trade negotiations as other trade barriers. This is despite the fact that export taxes often occur when food prices are high and/or volatile. Where export taxes have attention in the literature tends to be in studies that examine only a single commodity or country. Our work here seeks to provide more detail to investigating the linkages between export taxes, trade, and food prices. To do so, we utilize both a partial equilibrium model using a econometric-based gravity framework and a global general equilibrium model, which, in tandem, capture different aspects of these linkages. Our results show that export taxes do not have a widespread impact on international prices, but rather that the impact is concentrated in few goods. With our partial equilibrium model, we observe a positive impact on prices of dairy products, live plants, vegetables, oilseeds and oils. In contrast, with our computable general equilibrium model, the positive impact on prices is verified on wheat, coarse grains, and cattle and beef. A removal of export taxes currently in place would not have a significant impact on global prices, and would benefit regions currently applying taxes by an increase in production and exports and a reduction in poverty. However, some regions, mainly those that currently export commodities taxed in other countries, could be harmed by the removal of export taxes due to th the increased competition of exports in international markets, although they could benefit from a fall in domestic prices. These, global results highlight the need to consider the general equilibrium effects of the removal of export taxes.

Keywords: export taxes, agricultural prices, gravity model, partial equilibrium, CGE, poverty

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[1] The views expressed herein are those of the authors and not of the Economic Research Service or the United States Department of Agriculture.

1. Introduction

Governments generally encourage exports as an important source of national income and production, which implies they are more likely to subsidize exports rather than to tax them. Export subsidies, however, have been declining in use and are scheduled to be eliminated in the near future (Beckman et al., 2017). Meanwhile, export taxes are still used often; in particular, in times of high agricultural commodity price volatility. Estrades et al. (2017) note that in the agriculture sector, export taxes are the most numerous of export restrictions (e.g., export bans, export license requirements, and price references for export), with more than 400 instances of export taxes in place across the 2008-2014 time period. Although they are only used by 36 countries, those countries tend to be of two types: major grain exporters, and impoverished importers of agricultural commodities. In addition, the commodities that tend to have export taxes in place are rice and grains, which suggest possible linkages between export taxes, commodity price volatility, and food security.

Export taxes have received less scrutiny in multilateral trade negotiations than other, more visible trade instruments such as tariffs, tariff-rate quotas, and export subsidies. This is in part because they do not actually restrict market access, but rather, they restrict the amount of products on the world market. In addition, several decades of low and stable prices, and the desire for market access shown the trade policy light on the other trade instruments. However, the volatility in agricultural commodity prices in 2006-08 and 2010-11 reignited the debate on the response of governments to volatile and higher prices.[2] Although academics have long argued against government intervention due to the possibility of aggravating the volatility or exacerbating shortages (Gouel, 2014), some governments do implement policies to reduce price volatility (Poulton et al., 2006). These

[2] As to the causes of the price changes, Abbott et al., 2009 and 2011 note that there were multiple factors generated by complex global economic issues (e.g., biofuels production, exchange rates, supply constraints).

policies have revolved around some mixture of price insulating measures such as food subsidies, stockholding, or trade policy adjustments. Export taxes were among these measures. Evidence suggests that export taxes, together with other price insulating policies helped exacerbate the increase in global food prices in the second half of the 2000s (Martin and Anderson 2012; Anderson and Nelgen 2012; Jensen and Anderson 2014; Giordani et al., 2016; Mitra and Josling 2009; Solleder 2013; Headey 2011).

In a context of increasing food prices, export taxes are usually applied in order to isolate domestic prices from the world market and thereby to prevent domestic prices from rising. When a food exporting country imposes export taxes, there is an excess of domestic supply, which lowers domestic prices. If the country imposing the measure is a large exporter of the good (i.e., it has market power in the global market), the measure is expected to have an impact on international prices, as export volumes fall. The increase in international prices could also take place when many small exporters apply such measures (see Bouët and Laborde (2010) for a theoretical presentation of the partial equilibrium effects of export taxes). Globally, export taxes create distortions that have negative impacts on welfare; Laborde et al. (2013) find that removing all existing export taxes would lead to welfare gains of about 33 billion dollars per year.

The food price volatility issue is especially pertinent for export taxes since these barriers can particularly impact countries that depend on imports. Many poor countries in the developing world are very reliant on food imports, with poor populations particularly vulnerable to food prices volatility. To better understand how export taxes impact food consumers in certain countries (developed, developing, and food-importing) we provide an analysis of the effects of these restrictions using several different methodologies. Using information on actual export taxes in place, we first analyze the effects that they have had in terms of reducing actual trade volumes and prices. We apply a gravity framework across the breadth of agricultural commodities to assess the impact of export taxes on traded value and traded volume. We then use a general equilibrium model (CGE) to estimate the impacts of export taxes on commodity prices and trade. We first conduct a historical comparison to examine how well the model performs, then we examine how price volatility is impacted by export taxes. Because export taxes might impact the most vulnerable food consumers, we use a CGE framework capable of detailing the impacts to individual strata of income classes for several developing countries. This detailed poverty information is used to show the role that export taxes as applied to agricultural products play in the link between trade and poverty. Finally, to complete our assessment of export taxes and trade, we use the CGE model to examine the global impacts of removing export taxes.

2. Background

The evidence on price insulating policies exacerbating commodity price volatility is not conclusive, but Gouel (2014) notes that countries that implemented these policies tended to weather the food price crisis the best. However, the countries mentioned in his work (China and India) are large agricultural producers with the ability to implement policies; countries that are dependent on food imports were not as insulated (Abbott (2010) cites Ethiopia and Malawi as examples).

Demeke et al. (2009) examined short term measures applied by 81 developing countries in the context of higher international prices (2007-2008). They found that one of the most applied policy responses was a reduction in tariffs (more than half of the countries implemented this policy), which is not a trade distorting policy, but might produce an increase in world prices as domestic demand rises. Another popular policy was the imposition of export taxes or quantitative restrictions, with 25 countries imposing this type of trade restrictions, which might have exacerbated the increase in international prices.[3]

Given the effects of export taxes on global welfare, many efforts have been made in recent years to have a clear picture of the number and extent of export taxes applied during the food crisis, as well as its impact on food prices. OECD built a database that focus on the period 2007-2012, which includes all type of export restrictions (export taxes and surtaxes, export quotas, export bans, non-automatic licensing requirements, reference export price, other export measures). Their focus is on big countries that have an incidence on global prices (OECD, 2015). Another recent effort was the Panel Export Tax (PET) database, which includes information only on export taxes and on nine exporting countries (Solleder, 2013). Laborde et al. (2013) also built a database only focusing on export taxes at the exporter/HS level, which includes all countries for which there is available information. More recently, Estrades et al. (2017) built a comprehensive database which includes all type of export restrictions applied between 2004 and 2014 at the exporter/HS level, considering agricultural products and all countries in the world.

The database built by Estrades et al. (2017), known as the Export Restrictions in Agriculture (ERA), indicate that export taxes were the most numerous of all export restrictions from 2005-2014. As shown in figure 1, there is a peak in the number of products affected by export taxes in 2008, and another peak in 2012 and 2013. The figure also shows a global average for food prices. The two lines seem to move in unison; indeed, the correlation coefficient is 0.86.

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[3] Other short term policies applied in the period were releasing food stock to the market; VAT reduction; and price controls.

Figure 1. Number of export taxes in place and the FAO food price index (2005-2014)

Apart from figure 1, evidence suggests that export taxes, together with other price insulating policies, contributed to an overall increase in food prices (Mitra and Josling 2009; Headey 2011; Martin and Anderson 2012; Anderson and Nelgen 2012; Solleder 2013; Jensen and Anderson 2014; Giordani et al. 2016). However, the causality is difficult to evaluate, as export taxes are usually applied in the context of volatile prices. In addition, most studies focus on only a few markets (usually, grains and oilseeds).

Our paper seeks to contribute to the literature that estimates the impact of export taxes on agricultural international prices and trade. To do so, we apply different methodologies in order to capture the partial and general equilibrium effects of the policies, and we also estimate the impact on poverty indicators. Usually either a gravity model or a CGE model is used to examine policies (due mostly to space limitations in journals); however, their joint application can increase confidence in our results. Both have their benefits. The gravity model takes an ex-post approach to perform trade policy analysis (i.e., measuring the effect on trade flows of a past trade policy), and they are well-grounded in the empirical tradition of trade policy analysis. By contrast, CGE modeling takes an ex-ante approach, which involves quantifying the future effects of a new policy and rests on strong microeconomic theoretical foundations. The joint application of both methodologies has been utilized by DeRosa and Gilbert (2006) and Ivus and Strong (2007).

3. Methodology: Gravity Model

In order to analyze the impact of export taxes on traded volumes and international prices, we first apply a gravity model. The gravity model of trade argues that trade flows strongly depend on the distance between the two partners and the economic size of each other. The distance between countries stands for the variations in trade costs among dyads, and is often complemented with other factors affecting bilateral trade costs. We are specifically interested in the effects that trade policy costs have on traded flows, so we include import tariffs in a typical specification for a gravity model. Lacking direct information on prices we intend to infer the effects of export taxes on prices on the basis of their effects on traded values and traded volumes. We use the ERA database, with highly disaggregated data (six-digits of the Harmonized System) for export taxes. We also include information on tariffs applied, taking information from the Trade Analysis Information System (TRAINS). For each origin-destination-product we observe exports (values and volumes), export taxes, and import tariffs at the year level for the period 2005-2013.[4] Trade information comes from CEPII-BACI database, measured in current U.S. Dollars.

The main difficulty that arises when estimating the effects of policy barriers on trade comes from the fact that protective measures tend to be applied in sectors and periods in which the potential trade flow is higher, producing a reverse causality problem that

[4] We have 8,297,080 origin-destination-product panel units, which pooled for a nine-year period gives a comparatively large dataset of 74,673,720 observations.

would make the estimations inconsistent.[5] This is a source of endogeneity both when explaining traded volumes and traded values, but the problem should be even more serious in the case of values due to the role of prices, since an increase of international prices can have a positive impact on the probability of imposing trade policies (Giordani et al., 2016). Our strategy deals with endogeneity issues by applying the strategy proposed to dynamic panel data models by Holtz-Eakin et al. (1988) and popularized by Arellano and Bond (1991). Seeing the model as a system of equations, one per year, they propose to instrument each equation with a variable amount of available lags (increasing as t grows), which means that all the possible orthogonality conditions may be used. The resulting estimator is known as Difference-GMM and is used in this paper to estimate the dynamic panel gravity model.

A major advantage of this strategy is that it also provides a way to deal with the endogeneity of other included explanatory variables, both with internal instruments and external instruments in case they are available. The procedure to instrument these variables can be analogous to the one used for the lagged dependent variable ("GMM style") or can instrument the variables with their own lags ("IV style"). In our case this is critical, because both export taxes and tariffs are likely endogenous because of reverse causality, since countries tend to protect themselves in products that are intensely traded.[6]

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[5] Note that the effect from export taxes to trade being presumably negative, and the reverse causality effect (trade on export taxes) being presumably positive (more protection in relevant goods), the sign of the asymptotic bias is the sign of the reverse effect, positive in our case (see e.g. Basu 2015). Thus, this asymptotic bias caused by reverse causality offsets (at least partially) the negative bias caused by unduly omitting import tariffs in the model (as done in most of the extant studies on the effects of exports taxes).

[6] Despite these advantages, two important limitations have to be signaled. On one hand, we are not fully able to introduce the recommended fixed effect in order to control for multilateral resistance terms, as having to instrument every included variable, all the fixed effects incorporated must be added as instruments, rapidly causes a problem known as instruments proliferation which invalidates the results. Thus, we only include year fixed effects in our specifications, and we then test for robustness when including the necessary fixed effects (although we can no longer control for endogeneity). On the other hand, since there is no trade for 93 percent of total origin-destination-product observations in a typical year of our sample, it is worth noting that our dependent variable is strongly censored. Censoring and selection are challenging features within the framework of the dynamic panel data models.

The estimated equation is:

$$\Delta X_{ijht} = \alpha_1 \Delta X_{ijh(t-1)} + \sum_{q=0}^{1} \beta_q \Delta Xtax_{ijh(t-q)} + \sum_{q=0}^{1} \delta_q \Delta Mtar_{ijh(t-q)} + \theta_1 \Delta Xtot_{ih(t-1)} + \theta_2 \Delta Mtot_{jh(t-1)} + \tau_t + \Delta\varepsilon_{ijht} \quad (1)$$

Where X_{ijht} is the log of exports of product h from country i to country j in period t; $Xtax_{ijht}$ is the log of export taxes imposed by country i when exporting product h to country j (expressed as 1+rate before transformation); $Mtar_{ijht}$ is the log of import tariffs imposed by country j when importing product h from country i (expressed as 1+rate before transformation); τ_t are specific time effects, $\eta_{ij} + \varepsilon_{ijt}$ is an error term including a pair-product specific time-invariant unobserved effect and a reminder disturbance term assumed to be clustered at the pair-product (i, j, h) level. As a gravity model of trade, our specification requires the inclusion of the economic size of the partners in each specific sector. Since production and consumption data are unavailable at any disaggregated level for our country sample, we compute total exports in sector h from each origin ($Xtot_{iht}$) and total imports in sector h for each destination ($Mtot_{jht}$).

The complete set of orthogonality conditions for equation (1) when instrumenting first differences in policy variables with their lags in levels, is given by:

$$\begin{aligned}
&E\left[X_{ijh(t-s)}\Delta\varepsilon_{ijht}\right] = 0 && \text{for } s = 2, \ldots, t-1;\ t = 3, \ldots, T \\
&E\left[Xtax_{ijh(t-q-2)}\Delta\varepsilon_{ijt}\right] = 0 && \text{for } q = 0, 1 \\
&E\left[Mtar_{ijh(t-q-2)}\Delta\varepsilon_{ijt}\right] = 0 && \text{for } q = 0, 1 \\
&E\left[Xtot_{ih(t-1)}\Delta\varepsilon_{ijt}\right] = 0 && \\
&E\left[Mtot_{jh(t-1)}\Delta\varepsilon_{ijt}\right] = 0 && \\
&E\left[\Delta\tau_t\Delta\varepsilon_{ijt}\right] = 0 && \text{for } t = 3, \ldots, T
\end{aligned} \quad (2)$$

Alternatively, when first differences in policy variables are instrumented using GMM style, the second and third equations in the set of orthogonality conditions (2) have to be replaced by:

$$E\left[Xtax_{ijh(t-q-s)}\Delta\varepsilon_{ijt}\right] = 0 \qquad \text{for } q = 0,1;\ s = 2,\dots,t-1;\ t = 3,\dots,T$$
$$E\left[Mtar_{ijh(t-q-s)}\Delta\varepsilon_{ijt}\right] = 0 \qquad \text{for } q = 0,1;\ s = 2,\dots,t-1;\ t = 3,\dots,T \qquad (3)$$

Our preferred set of instruments vary by sector, according to their performance in terms of the validity of the overidentifying restrictions (Sargan, 1958; Hansen, 1982) and the lack of serial correlation (Arellano and Bond, 1991). In some cases we use GMM style with a shorter span of lags as instruments, in other cases we use IV style with closer or farther lags as instruments, or we even use no instruments for policy variables when specification tests indicate so.

Three other variations are used to reach an adequate performance of each regression. In some cases we use forward orthogonal deviations instead of the first differences transformation. In other cases we allow for a longer dynamic structure in the model (two lags of the dependent variable). Finally, for some sectors we had to collapse the matrix of instruments in a way that makes the instrument count to increase linearly with the total number of periods.[7]

3.1 Estimation Results

In table 1 we present a summary of our baseline results, reporting the degree in which we have evidence of a price effect of each policy measure. The details of the estimated coefficients for each policy variable are presented in Estrades et al. (2017). The main conclusion is that the expected price effects are not observed in many sectors, and when there is some evidence it is generally weak. We refer hereafter as “strong evidence” of a price effect when we find that an export tax reduces traded volumes more than traded values (which could even increase) or when volumes are not affected but values increase.

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[7] This method is equivalent to projecting the explanatory variables onto the full Arellano-Bond set of instruments, while constraining the coefficients on certain lags in the projection to be null (Roodman, 2008). All the estimations were done using the command xtabond2 (Roodman, 2009) in Stata 14 MP. The computations were performed at University of Geneva on the Baobab cluster.

In order to compare the elasticity of a policy measure on values and quantities, we compute a simple test for equality of means of the two estimated coefficients. In some cases there is no statistically significant difference between the two coefficients, but a seemingly contradictory result shows that one of them is statistically equal to zero, while the other is not. We will refer to these cases as having “weak evidence” of a price effect. Almost 75 percent of the price effects we detect fall in this last category. A final situation is when both the effect on quantities and values are significant, we fail to reject equality of the two coefficients, but there is a noticeable difference between the two of them, and we refer to these cases as giving “very weak evidence” of a price effect.

All sorts of evidence of price effects are signalled in table 1 shadowed cells. Our main results show that export taxes have a negative effect on traded volumes and a positive effect on prices for Dairy products; Edible vegetables; Oilseeds and oleaginous fruits; Fats and oils; Sugar; Miscellaneous edible preparations; Beverages and spirits; and Residues and waste from the food industry.

For some of these sectors, only few countries imposing export taxes explain the impact on prices. In some cases, as few as one or two: Argentina for Live trees and plants; Pakistan for Sugar, Argentina for Dairy products; Kenya and Nepal for Edible preparations; and Kenya and Russia for Beverages and spirits. In the case of Edible vegetables, three countries imposed export taxes in the period: Argentina on various vegetables; Nepal on lentils; and Pakistan on leguminous and potatoes. Then, for Oilseeds and oleaginous fruits; Fats and oils; and Residues and waste from the food industry, many different countries apply export taxes on various products: five countries apply export taxes on Fats and oils; seven countries on Residues and waste from the food industry; and ten countries apply export taxes on Oilseeds and oleaginous fruits.

The cases of no evidence of a price effect come from two different situations. In most occasions we have clearly similar effects on values and quantities, which means that prices are stable. In other sectors we find that export restrictions lead to a fall in prices (a significant negative effect on values accompanied by no effects on quantities) or tariffs produce an increase in prices. These results are counterintuitive and opposed to the predictions of a basic partial equilibrium model. However, different stories could explain this kind of pattern. One possible explanation is a composition effect, where a restriction applied to an eight-digit product leads to an increase in exports of another eight-digit product which pertains to the same six-digit category and has a higher unit value. A related rationalization would be a general equilibrium effect, where the restrictions make exporters to switch to other products in a different six-digit category in which some eight-digit products are also facing restrictions. A third motive is a substitution of one restriction with another, like the replacement of an export tax with an export quota which would affect the estimation of both coefficients, since the reduction of export taxes is not followed by an increase in volumes and the quota does not necessarily produce a further decrease in exports.[8]

The use of a dynamic model allows to describe different time patterns of the price effects, which could be observed immediately (in t) or with some delay (in t+1). Also, an immediate effect can be reinforced in the following period, or contrarily, it could be a transitory effect that is quickly reverted. With the exception of Oilseeds and oleaginous fruits, in which there is a delayed effect of export taxes, in all cases the impact takes place

[8] Note that blank cells do not mean that there is no price effects. In these cases the identification of the effects was not possible, because of lack of observations of the particular measure for the particular product. This can happen because measures have not been applied by any country, or they have been but very early in our time sample (and the first observations are lost because of the lags required by the model), or they have been in place but stayed unchanged during the whole period (and our model identifies this parameters on the basis of variations). Our database has some missing values in the tariff variables, and this forces to drop these observations and some export taxes could be also lost for this reason.

in the same year the measure is implemented. Among Fats and oils, the effect takes place the same year the measure is implemented, and the effect is reinforced the following year.

Table 1. Summary of the evidence of price effects and export taxes by sector, GMM Estimations

SECTOR		EXPORT TAXES evidence of price effects	expected sign (increase)	dynamic pattern
1	Live animals			
2	Meat and edible meat offal	none		
4	Dairy prod; birds' eggs; natural honey; edible products of animal origin, NES	**weak**	**yes**	**in t**
7	Edible vegetables and certain roots and tubers	**weak**	**yes**	**in t**
8	Edible fruit and nuts; peel of citrus fruit or melons	none		
9	Coffee, tea, mate and spices	none		
10	Cereals	weak	no	in t
11	Products of milling industry; malt; starches; inulin; wheat gluten	none		
12	Oil seeds, oleaginous fruits; grains, seeds, fruit; ind or med plants; fodder	**weak**	**yes**	**in t+1**
13	Lac; gums, resins & other vegetable saps & extracts			
15	Animal/vegetable fats & oils & their cleavage products; edible fats; waxes	**weak**	**yes**	**in t** **reinf in t+1**
16	Preparations of meat, fish, crustaceans, mollusks, aquatic invertebrates	none		
17	Sugars and sugar confectionery	**weak**	**yes**	**in t**
18	Cocoa and cocoa preparations	weak	no	in t
19	Preparations of cereals, flour, starch/milk; pastrycooks' products	none		
20	Preparations of vegetables, fruit, nuts or other parts of plants	none		
21	Miscellaneous edible preparations	**weak**	**yes**	**in t**
22	Beverages, spirits and vinegar	**weak**	**yes**	**in t**
23	Residues & waste from the food industry; prepared animal fodder	**very weak**	**yes**	**in t**
33	Essential oils & resinoids; perfumery, cosmetic/toilet preparations			

A reduction of import tariffs has a positive effect on prices in fewer sectors, and the effect is verified the same year the reduction takes place (table 2). The positive impact on prices is verified for Live animals; Edible vegetables; Cereals; Cocoa and cocoa preparations; and Residues and waste from the food industry. In all those sectors, we observe a significant fall in applied tariffs in some years among the main importers for each sector. The fall in tariffs, which might not necessarily be a policy aimed to isolate domestic prices, is verified mostly in developed countries, although many developing countries also applied tariff reductions. For example, in Cereals, which, as already noted was one of the sectors in which many import countries reduced protection, we verify a fall in applied tariffs in Japan, European Union, Egypt, México and Korea, mainly in the years in which prices spiked. In the case of Residues and Waste from the Food Industry, we note a fall in protection applied by the EU and Vietnam, while in the case of Live animals, the main importers, U.S. and EU, also reduced protection. Finally, the European Union also applied tariff cuts on Edible Vegetables and Live Trees and Plants; whereas India applied tariff reductions on Edible Vegetables. We should keep in mind that that the EU and India are, respectively, the main importers in each sector. However, many small importers also applied tariffs cuts. This is one major difference between trade policies applied by importers and exporters is that for the former, as imports are usually less concentrated in a few countries compared to exports, the effect of price isolating policies on global prices is shared among more actors and responsibility is diluted. In spite of this, import-promoting policies do have an impact on global prices, at least in some sectors.

Table 2. Summary of the evidence of price effects and import tariffs by sector, GMM Estimations

SECTOR		IMPORT TARIFFS		
		evidence of price effects	**expected sign (decrease)**	**dynamic pattern**
1	Live animals	**weak**	**yes**	**in t**
2	Meat and edible meat offal	none		
4	Dairy prod; birds' eggs; natural honey; edible products of animal origin, NES	none		
7	Edible vegetables and certain roots and tubers	**weak**	**yes**	**in t**
8	Edible fruit and nuts; peel of citrus fruit or melons	none		
9	Coffee, tea, mate and spices	none		
10	Cereals	**very weak**	**yes**	**in t**
11	Products of milling industry; malt; starches; inulin; wheat gluten	none		
12	Oil seeds, oleaginous fruits; grains, seeds, fruit; ind or med plants; fodder	none		
13	Lac; gums, resins & other vegetable saps & extracts	none		
15	Animal/vegetable fats & oils & their cleavage products; edible fats; waxes	none		
16	Preparations of meat, fish, crustaceans, mollusks, aquatic invertebrates	none		
17	Sugars and sugar confectionery	none		
18	Cocoa and cocoa preparations	**weak**	**yes**	**in t**
19	Preparations of cereals, flour, starch/milk; pastrycooks' products	none		
20	Preparations of vegetables, fruit, nuts or other parts of plants	none		
21	Miscellaneous edible preparations	none		
22	Beverages, spirits and vinegar	none		
23	Residues & waste from the food industry; prepared animal fodder	**very weak**	**yes**	**in t**
33	Essential oils & resinoids; perfumery, cosmetic/toilet preparations	none		

4. Methodology: CGE Model

The complex interactions between agricultural commodity markets and trade policies, and the prominence of food in household budgets and real income determination, justifies the economy-wide, global approach of an applied general equilibrium (AGE) analysis, which offers a useful analytical framework to study the effects of recent high price volatility in agricultural markets. The commodities in question are heavily traded, and directly and indirectly consumed by households. Thus, by explicitly disaggregating the major producing and consuming regions of the world, we are better able to characterize the fundamental sources of volatility in these markets.

From Jorgenson's (1984) insight into the importance of utilizing econometric work in parameter estimation, to more recent calls for rigorous historical model testing (Kehoe, 2003; Grassini, 2004), it is clear that CGE models must be adequately tested against historical data to improve their performance and reliability. The article by Valenzuela et al. (2007) showed how patterns in the deviations between CGE model predictions and observed economic outcomes can be used to identify the weak points of a model and guide development of improved specifications for the modeling of specific commodity markets in a CGE framework. More recent work by Hertel and Beckman (2011) and Beckman et al. (2012) has focused on the validity of the GTAP-E model for analysis of global energy markets. Accordingly, we begin our work with a similar historical validation exercise. In particular, we examine the model's ability to reproduce observed price changes in global commodity markets.

4.1 Applied General Equilibrium Model:

The use of trade instruments, such as export taxes, are far-reaching, affecting all sectors of the economy and trade, which creates potential market feedback effects. To capture how these affect households, we use a global CGE model, in particular, the GTAP-POV model (Hertel et al., 2015). This model features a macro-modeling framework that nests a poverty module within the GTAP modeling framework. This allows users to assess the impact of global trade on poverty across seven different 'strata' or sub-populations within focus countries. The GTAP-POV version substantially extends the standard GTAP model, in order to explore the linkages between agricultural reforms under the WTO and the distribution of income among farmers in rich and poor countries. Key modifications made by Hertel et al. include:

- Incorporation of factor supply and demand features from GTAP-AGR (Keeney and Hertel, 2005)
- Incorporation of AIDADS demand system for modeling consumer demand in each country
- Incorporation of additional tax replacement instruments
- A farm household income module with a detailed livestock-feed nesting structure; and the poverty module for looking at poverty impacts in 15 focus countries.

4.2 Experimental Design

The GTAP data base used here (v.6) is benchmarked to 2001, which while is not very suitable for scenario analysis, does provide a nice platform for validating the model. To do so, we undertake a historical update experiment following Beckman et al. (2011) to update the model to 2008, the last year of the several years of high commodity prices from 2006-08. Those authors show that by shocking population, labor supply, capital, and investment (see table 3), along with the relevant energy price shocks, the result is a reasonable approximation to key features of the more recent economy. The shocks shown in the table are generally positive, as economic and population expansion helped drive some of the agricultural commodity price increase over the time period. There are some negative values, primarily to Japan (see Appendix 1 for the regional mapping) for investment and labor; and to XER (Rest of Europe) for population and labor.

Table 3. Exogenous shocks to update the model to 2008

	Population	Investment	Labor	Capital	GDP
AUSNZL	12.36	46.66	17.23	28.18	26.80
CHN	4.26	20.41	7.88	119.48	107.44
JPN	1.07	-6.14	-0.73	5.46	8.75
DVDASIA	4.98	-2.20	8.94	36.46	37.70
IDN	10.51	43.11	13.02	34.02	44.57
PHL	13.96	-4.12	12.96	24.03	42.14
THA	4.94	21.25	9.37	29.44	42.01
VNM	6.90	20.69	12.99	103.57	67.66
XSE	12.97	51.21	19.38	25.39	51.11
BGD	9.83	6.59	15.13	60.28	49.13
IND	10.87	30.78	14.87	82.31	64.77
PAK	13.72	32.71	28.10	45.91	42.63
XSA	15.16	20.97	16.19	42.55	52.20
CAN	7.69	18.57	13.52	27.42	17.87
USA	6.65	-6.35	6.44	24.09	16.11
MEX	9.14	12.20	17.95	26.91	20.57
XCA	11.75	20.65	19.40	30.52	37.89
COL	11.33	52.34	19.12	38.33	38.75
PER	8.54	41.57	14.89	22.47	57.86
VEN	13.07	-6.61	21.66	15.91	38.01
BRA	8.36	14.10	17.56	16.58	31.34
CHL	7.62	19.12	24.04	35.28	34.83
XSM	8.97	21.12	16.52	22.47	41.60
EUEFTA	3.33	5.18	7.58	16.51	14.74
XER	-2.22	44.70	-5.72	30.90	47.69
FrmUSSR	-0.21	32.75	6.83	4.04	62.05
MENA	13.43	34.03	22.74	33.10	48.49
ZAF	10.45	55.80	18.74	21.97	35.68
MWI	21.64	76.38	19.72	44.21	40.07
MOZ	21.17	-16.12	17.37	53.45	66.18
TZA	21.37	75.55	20.78	54.49	62.94
ZMB	20.21	12.94	17.23	41.32	44.26
UGA	26.67	21.41	26.43	87.59	71.67
XSS	20.23	17.19	22.29	24.54	50.85

Source: Foure et al., 2013

The energy price shocks are not presented in the table, but they are (U.S. prices, as reported by the Energy Information Agency): Oil: 225 percent, Natural Gas: 75 percent, and Coal: 100 percent. Note that we do not directly shock agricultural commodity prices, as these are the measure with which we use to validate the model.

The focus of this paper is to better understand the impacts from export taxes. To properly consider the model's ability to replicate commodity price changes through export taxes, we use the export restriction database from Estrades et al. (2017), and shock the model for the changes in export taxes from 2001-up to 2008.[9] Doing so gives us two measures of the model's ability to replicate price changes: a model with only the exogenous shocks listed in Table 3; and a model that adds changes in export taxes to those exogenous shocks.

4.3 Results for the Historical Validation

Our first task is to examine the performance of the model with respect to the updating scenario. The first of column in table 4 indicates the 'historical' price change. This is based on food (or consumer) price indices from different sources listed in the regions name. This data highlights the fact that prices have been highest in Venezuela and many of the African regions. By comparison, prices were very stable in Japan (2.4 percent). The final two columns report the model-generated percentage change in commodity. These results are built on the construction of a 'food basket' price for GTAP results. This household food basket is built on the share of agricultural consumption for each region, with the Other Food and Beverages (OthFdBev) sector accounting for more than 50 percent of the share in developed countries and about 25 percent in developing countries. The model results indicate that the exogenous shocks alone do not get us to the historical price change for food, except for a handful of countries: China (CHN), Developed Asian –countries (DVDASIA), Thailand (THA), Rest of South and East Asia (XSE), India (IND), Canada (CAN), and European countries (EUEFTA and XER). In most cases, the predicted price change is smaller than the historical shock, which reflects the fact the model cannot

[9] The baseline for the model is 2001, while the Estrades et al. (2017) database is from 2004-2014. To reconcile the two, we take the baseline taxes and apply any changes that Estrades et al. report for 2008.

capture other drivers of large price changes. In very few cases, the predicted change in prices is higher than the observed, which might highlight the fact that the model might not be capturing price isolating policies applied in those countries (Japan (JPN) and IDN (Indonesia)).

Table 4. Historical and model generated food basket price changes, 2001-2008

		Model estimates	
	Historical	Exogenous shocks	With export taxes
AUSNZL (OECD)	30.10	17.84	23.05
CHN (OECD)	52.62	59.17	58.64
JPN (OECD)	2.43	13.22	17.45
DVDASIA (OECD)	31.99	21.81	26.21
IDN (OECD)	95.02	108.61	22.58
PHL (FAO)	43.09	23.04	25.08
THA (WB)	24.26	23.77	26.22
VNM (WB)	79.06	21.55	24.70
XSE (WB)	19.79	27.31	30.11
BGD (WB)	59.53	20.05	21.30
IND (WB)	43.41	37.38	38.27
PAK (WB)	73.99	20.23	21.25
XSA (WB)	48.66	31.66	30.79
CAN (OECD)	18.12	9.38	77.81
USA (OECD)	23.51	7.00	13.82
MEX (OECD)	47.85	5.79	9.99
XCA (FAO)	69.21	14.94	20.00
COL (FAO)	72.65	17.41	22.89
PER (FAO)	22.75	29.03	32.83
VEN (WB)	326.05	17.55	20.70
BRA (OECD)	70.84	14.87	19.67
CHL (OECD)	39.99	12.23	14.88
XSM (WB)	93.07	20.97	23.32
EUEFTA (OECD)	18.72	13.25	18.26
XER (FAO)	20.25	18.64	23.04
FrmUSSR (OECD)*	63.16	31.12	40.10
MENA (OECD)	186.00	20.00	24.87
ZAF (OECD)	76.36	20.11	26.65
MWI (WB)	115.02	16.55	19.21
MOZ (WB)	116.12	23.43	24.28
TZA (WB)	54.44	27.33	28.67
ZMB (WB)	180.98	25.30	25.63
UGA (WB)	57.05	23.89	23.96
XSS (FAO)	44.10	22.83	25.32

Note: The parenthesis represents the source of the data. OECD is the Organization for Economic Co-operation and Development; FAO is the Food and Agriculture Organization of the United Nations; and WB is the World Bank. * refers to prices from 2004-2007.

The final column indicates the changes in the food basket price with export taxes are overlaid on the exogenous shocks. In general, export taxes increased from 2001-2008 for any region using them. These results show that export taxes added around 5-10 percent to price increases across regions, except for China, Rest of South East Asia, and to a much larger extent, Indonesia. The decrease in food prices in those countries indicates that export taxes did actually insulate the countries from the global price changes, especially for Indonesia.

The next table shows global price changes across commodities. For grains and derivatives of grains, prices shown in table 5 are greater than 100 percent. The second and third column show the CGE model generated price changes. Again, the differences between the CGE predicted price increase and the historical figures highlight the fact that the model is not capturing the main driving forces behind the surge in prices, mainly for grains. When export taxes are overlaid on the exogenous shocks, wheat, coarse grains, cattle and beef are particularly impacted. On the other hand, fish and forest products are not affected by export taxes.

Table 5. Historical and model generated commodity price changes, 2001-2008

	Historical	Exogenous shocks	With export taxes
Rice		21.87	25.90
Wheat	169.76	22.84	33.16
Crsgrns	149.14	21.48	32.38
Oilseeds	168.62	22.10	30.17
Sugar		30.85	34.81
Cotton	48.76	24.39	32.84
OthCrps		21.36	25.19
Milk		25.61	32.14
Cattle		16.84	27.22
NRumin		20.09	28.75
Fish	67.71	62.29	56.02
Forest	10.71	21.32	21.12
PrDairy		12.04	20.61
PrBeef	25.44	13.50	26.54
PrNRumn	19.11	13.96	22.47
PrSugar	28.70	14.72	23.31
PrRice	305.43	18.94	22.88
PrOilsd	263.30	22.04	23.71
OthFdBev		12.99	19.48

Note: The historical price changes are: Wheat: No.1 Hard Red Winter; Crsgrns: U.S. No. 2 Yellow; Oilseeds: U.S. soybeans, Chicago futures; Cotton: Cotton Outlook 'A Index'; Fish: Farm Bred Norwegian Salmon; Forest: Soft Sawnwood; PfBeef: Australian and New Zealand 85% lean fores; PrNRumin: average of: 51-52% lean Hogs and Whole bird spot price; PrSugar: European import price; PrRice: 5 percent broken milled white rice; and PrOilsd: Rapeseed oil, crude.
Source: IMF Primary Commodity Prices

Next we look at commodity price changes within each region. To do so, we take the difference between domestic prices and world prices for both the updating scenario and the updating scenario with export taxes such that:

$$(pd_i^{tax} - pw_i) - (pd_i^{notax} - pw_i) \qquad (4)$$

With *pd* representing the domestic price and pw the world price, so that the world price is filtered out. Figure 3 conveys the results by how strong the effect is. One '+' indicates a single digit increase,' ++' is a double digit increase and '+++' is a triple digit increase, the same magnitude is given for negative (-) changes. The figure also indicates if that region had an export tax in place for a given commodity (denoted by the asterisk).

pm	Rice	Wheat	Crsgrns	Oilseeds	Sugar	Cotton	OthCrps	Milk	Cattle	NRumin	Fish	Forest	PrDairy	PrBeef	PrNRumn	PrSugar	PrRice	PrOilsd	OthFdBev
AUSNZL	+	++	+	+	+	+	+	+	+	+	--	-	+	++	+	+	+	+	+
CHN	+*	++*	+*	+*	+	++	+	+	+	+	--	-	+	+	+	+	+*	+*	+
JPN	+	++	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	++	+
DVDASIA	+	++	+	+	+	+	+	+	+	+	--	-	+	+	+*	+	+	+	+
IDN	--	-	--	--*	--	--	--	--	--	--	--	--*	---	---	---	---	--	---*	---
PHL	+	++	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	-	+
THA	-	+	+	+	+	+	-	+	+	+	+	--	+	+	+	+	+	+	+
VNM	+*	++*	+	+	+	+	+*	++	+	-*	-	-*	-	-	-	-	-*	+	-*
XSE	-	--	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	++*	+
BGD	+	++	+	+	+	+	+	+	+	+	-	-	+	++	+	+	+	+	+
IND	-	++	+	+	+	+	+	+	+	-	-	--	+	+	+	+	+	+	+
PAK	+	++	++	+	++	++	+*	+*	+	-*	+	-	+	+	-	+	+	+	+*
XSA	+	++	+	+*	+	+	-*	+*	+	-	-	-	+	+	+	+	+	+	+
CAN	+	++	++	++	+	++	++	++	++	++	++	+++	++	++	++	++	++	++	++
USA	+	++	++	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+
MEX	+	++	+	+	+	+	+*	+	+	+	-	+	+	+	+	+	+	+	+
XCA	+	++	+	+	+	+	+*	+*	+*	+	-	+	+	+	+	+	+	+	+
COL	+	++	+	+	+	+	+	+	+	+	-	+	+	++	+	++	+	++	+
PER	+	++	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
VEN	+	++	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	+
BRA	+	++	+	+	+	+	+	+	+	+*	+	+	+	+	+	++	+	+	+
CHL	+	++	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+
XSM	+*	+*	+*	-*	+	+*	+*	+*	+*	+*	-	+*	+*	+*	+*	+	+*	+*	+*
EUEFTA	++	++	++	+	+	++	+	++	+	+	-	+	+	+	+	+	+	+	+
XER	++	+	+	+	++	++	++	++	++	++	-	-	+	+	+	+	++	++	+
FrmUSSR	+	++*	++*	+*	++	++	+	++	+*	++*	--	-	++	++	++	++	++	++*	++*
MENA	+*	++	+	+	+	++	+	++	+	+	--	-	+	++	+	+	+	++	+
ZAF	+	++	++	+	+	++	+	++	+	+	-	-	+	++	++	+	+	+	+
MWI	+	++	+	+	+	+	+	+	+	+	-	-	+	++	+	+	+	+	+
MOZ	+	++	+	+	+	+	+	+	+	+	--	-	+	+	+	+	+	+	+
TZA	+	++	+	+	+	+	+	+	+	+	--	-	+	+	+	+	+	+	+
ZMB	+	++	+	+	+	+*	+	+	+	+	--	-	+	+	+	+	+	+	+
UGA	+	++	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	+
XSS	+	++	+	+	+	+	+*	+	+	+	--	-	+	+	+	+	+	+	+

Figure 3. Price differentials across regions and commodities

The information from the figure suggests that export taxes have insulated few regions or commodities from world prices. Out of the 57 instances of export taxes shown in the figure, in only 7 was the domestic price with no tax greater than the domestic price with a tax. Of these 7 instances, the only region that was insulated by double digits was Indonesia. And the export tax policies of Indonesia has major bearings on commodities. For example, Indonesia is insulated by double-digits for most commodities. However, all other regions had to face higher domestic prices because of their export tax. In total of the 646 region/commodity pairings, domestic prices were higher relative to global prices with export taxes in only 79 of the case. And many of these were for fish and forestry.[10]

All of this validation work set the stage for better understanding how the model works. Clearly, the model is not able to account for all price surge drivers, but it does show that export taxes seem to have influenced commodity prices from 2001-2008 for certain sectors. Next, we provide an in-depth exploration of the role of trade policy regimes in governing the extent to which volatility is transmitted to agricultural commodity markets, following the work by Hertel and Beckman (2011). As shown in their work, supply-side volatility is by far the largest contribution to commodity price variation, thus we focus solely on this aspect.

4.4 Characterizing Sources of Volatility in Agricultural Markets

To characterize the systematic component in agricultural production, time-series models are fitted to FAO data on annual production over the time period of 1981-2008. The summary statistic of interest from the time-series regressions is the normalized standard deviation of the estimated residuals. This result summarizes variability of the non-

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[10] Note that the regions that have the positive differential between domestic and global prices are those who have export subsidies in place in 2008. See Beckman et al. (2017) for information on countries that have export subsidies.

systematic aspect of annual production in each region. This is calculated as $\sqrt{variance}$ (of estimated residuals) divided by the mean value of production, and multiplied by 100 percent.[11] This stochastic component is then used in our model to estimate the changes to food prices across regions. The distributions of the stochastic shocks to agricultural production are assumed to be normally and independently distributed.

The key result of interest from the time-series regressions is the normalized standard deviation of the estimated residuals, reported in table 6. A couple of patterns emerge from this work. Field crops (rice, wheat, coarse grains, oilseeds, sugar and cotton) have much higher variability in production than others crops and livestock. The global variability for field crops ranges from 2.99 to 7.08, while there is no estimate greater than 2 for non-field crops. There is also much more variation across regions for field crops. Field crops feature many regions that have double-digit estimates, while most non-field crop estimates are less than 10.

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[11] This is also called the coefficient of variation.

Table 6. Time-series residuals, used as inputs for the stochastic simulation analysis

	rice	wheat	coarse grains	oil seeds	sugar	cotton	other crops	milk	cattle	non ruminants
ausnz	31.49	28.75	22.42	17.52	9.15	24.20	3.87	4.00	4.58	3.97
chn	4.63	7.38	9.75	7.29	9.92	13.99	4.19	5.89	6.30	8.20
jpn	9.27	9.89	9.98	13.73	11.06	118.40	2.78	1.97	4.93	2.31
dvdasia	4.45	NV	11.71	7.25	15.17	23.15	4.04	4.66	11.77	4.33
idn	3.73	NA	14.46	12.29	7.02	11.22	10.99	7.22	8.80	12.24
phl	8.96	NA	8.45	11.17	12.20	10.42	4.92	8.64	8.73	8.10
tha	6.49	12.28	14.41	15.54	18.10	19.30	7.15	10.71	7.30	11.61
vnm	4.84	NA	10.53	7.05	13.94	14.88	2.42	10.74	11.18	13.08
xse	5.28	14.81	13.28	9.44	11.67	13.18	2.15	6.59	5.80	2.79
bgd	5.40	12.80	38.87	4.78	5.42	14.14	8.22	2.05	2.01	4.46
ind	8.70	6.89	12.97	11.49	9.70	12.87	6.98	2.01	1.42	6.85
pak	11.29	6.74	9.38	14.11	13.09	17.11	5.81	4.86	6.14	15.75
xsa	8.18	17.49	6.10	9.32	9.32	27.63	5.67	9.71	5.53	11.15
can	NA	13.56	9.45	18.28	NA	22.20	4.97	2.06	6.99	3.55
usa	11.07	13.66	16.07	10.38	6.53	17.40	4.12	1.63	2.86	2.63
mex	24.88	13.27	9.82	11.38	6.48	30.83	3.02	3.45	6.05	6.46
xca	7.02	34.43	5.43	6.72	8.42	18.16	4.23	2.35	3.74	5.69
col	9.43	NV	8.96	8.49	5.09	25.94	4.60	3.55	6.00	9.62
per	16.82	14.40	13.96	16.49	10.93	27.56	6.65	4.86	6.14	10.22
ven	16.59	27.00	16.79	15.75	9.32	29.16	5.58	8.49	9.55	13.85
bra	13.35	31.79	16.12	11.60	8.01	20.31	4.79	4.20	4.82	10.36
chl	29.94	15.42	14.20	42.05	NA	2.82	5.10	5.04	6.35	11.18
xsm	14.51	17.01	16.38	12.83	7.17	27.46	4.83	7.78	5.94	8.99
euefta	7.58	8.78	7.08	10.01	15.81	11.47	3.82	1.37	3.17	3.69
xer	27.72	27.87	18.72	28.58	NA	34.97	13.25	8.58	10.74	7.77
Frmussr	9.13	17.01	16.60	19.53	NA	8.37	6.69	4.46	5.23	7.31
mena	8.21	10.91	10.93	13.28	6.88	8.24	3.90	3.43	6.60	5.06
zaf	5.24	20.87	25.51	33.86	13.64	28.82	4.31	5.26	8.40	4.53
mwi	32.02	NV	29.16	25.12	12.44	37.68	5.69	16.13	16.17	16.27
moz	20.98	26.71	21.25	74.35	27.96	30.84	10.15	2.32	15.51	8.95
tza	17.13	26.99	22.64	12.73	9.27	22.15	15.07	5.98	11.31	9.24
zmb	17.23	23.71	28.05	22.90	9.26	42.83	4.82	10.04	13.31	5.09
uga	12.84	19.46	12.27	9.72	11.25	33.64	3.58	8.66	8.90	11.74
xss	8.75	14.39	9.81	4.38	3.54	9.06	3.30	4.74	4.02	4.96
global	2.98	5.27	7.08	4.79	4.78	7.57	1.99	1.02	1.82	1.85

Note: NA represents data that was not available. NV represents non-valid estimates, i.e., the stochastic estimate is so large that the model would not solve. Regions with either NA or NV receive the global estimate.

4.5 Stochastic Simulation Analysis

The time-series residuals are used in our CGE model to explore the agricultural commodity price transmission under export taxes. The results in table 7 reports the model-generated standard deviations in annual percentage change across agricultural commodity prices based on stochastic simulations undertaken using the Stroud Gaussian Quadrature as detailed in Person and Arndt (2000). They represent volatility in commodity production only. The time-series residuals only provide information on volatility in primary production, it is no surprise that these sectors are the ones with the largest amount of variation in commodity prices. A sector like Other Food and Beverages certainly uses these primary products as inputs into production, but there are other non-agricultural inputs. For

Table 7. Model-generated commodity price variation based on commodity production volatility

	Rice	Wheat	Crsgrns	Oilseeds	Sugar	Cotton	OthCrps	Milk	Cattle	NRumin	Fish	Forest	PrDairy	PrBeef	PrNRumn	PrSugar	PrRice	PrOilsd	OthFdBev
AUSNZL	3.33	5.62	7.24	15.77	11.51	7.65	4.31	4.48	5.21	3.92	1.18	0.11	2.02	2.25	1.53	0.71	0.77	0.38	0.38
CHN	7.83	10.22	19.50	9.13	16.46	17.26	7.64	8.86	11.83	12.75	14.86	1.03	2.48	6.27	10.25	9.35	3.20	4.44	2.67
JPN	11.86	10.64	10.56	15.88	13.65	8.15	3.57	2.77	7.03	2.52	0.36	0.06	0.58	1.97	0.52	1.93	6.67	3.01	0.31
DVDASIA	7.76	7.91	13.35	7.80	24.36	7.09	4.97	5.59	13.84	5.42	2.18	0.27	1.85	4.70	3.88	2.99	6.95	3.64	1.76
IDN	5.02	4.92	18.39	20.66	9.22	11.36	13.79	8.27	10.53	14.60	4.36	0.36	1.07	2.21	8.38	4.09	4.23	2.62	1.64
PHL	16.85	6.98	16.90	13.38	17.86	12.96	6.72	16.26	18.11	15.46	10.97	0.61	1.15	3.87	10.22	7.10	12.61	0.58	1.91
THA	7.41	12.75	16.06	19.80	21.01	20.99	7.34	11.60	7.99	12.30	1.39	0.64	3.24	1.95	7.66	8.09	6.01	1.40	0.56
VNM	6.14	5.99	11.74	6.77	17.77	15.90	2.33	11.20	14.19	15.30	6.50	0.95	1.41	2.28	8.66	9.34	6.13	0.78	1.11
XSE	8.04	20.46	22.30	12.47	20.08	17.11	2.78	9.79	7.84	3.64	1.85	0.15	0.90	2.07	2.30	7.58	5.68	0.23	0.47
BGD	7.31	14.46	7.32	5.39	6.67	13.40	10.29	3.77	3.81	5.44	2.95	3.40	1.74	0.67	0.64	3.12	5.12	2.99	2.90
IND	15.58	10.63	22.29	19.33	18.14	17.42	10.82	4.10	7.81	11.45	11.16	1.45	1.82	0.88	3.24	11.13	3.94	9.14	2.32
PAK	13.71	9.86	13.82	16.08	22.03	22.94	9.16	8.03	15.15	23.80	37.69	9.39	7.86	8.32	8.39	11.78	8.83	4.53	6.93
XSA	13.61	20.93	8.22	9.74	14.60	9.07	7.33	16.01	8.28	18.52	6.50	1.00	7.66	8.11	8.54	7.39	6.51	4.52	1.37
CAN	1.43	12.94	9.78	19.05	1.23	7.68	5.15	2.86	7.57	3.84	0.19	0.14	0.76	3.56	1.60	0.16	2.17	1.44	0.29
USA	13.14	14.37	19.21	11.90	9.05	20.82	4.71	4.28	4.87	2.95	1.14	0.07	1.33	1.83	1.03	1.00	1.27	3.66	0.35
MEX	3.45	14.30	11.37	11.82	7.55	8.03	3.67	4.22	6.66	7.54	3.12	0.08	1.22	1.03	2.46	1.90	0.44	5.44	0.74
XCA	9.13	6.49	6.87	8.19	12.00	23.49	4.11	3.24	5.55	7.41	2.57	0.16	0.93	2.28	2.99	1.36	1.60	3.07	0.53
COL	11.42	22.67	9.93	9.63	6.10	8.30	4.45	4.47	7.51	12.02	8.52	0.18	2.22	3.03	3.12	1.07	1.60	1.22	0.85
PER	20.59	16.47	16.02	19.34	12.93	8.32	8.12	5.84	7.66	12.23	2.22	0.45	0.42	1.88	1.89	2.26	1.75	1.78	1.10
VEN	21.99	6.99	24.16	18.68	11.27	8.69	7.97	10.62	12.92	26.33	10.96	0.31	7.25	4.65	0.84	5.15	0.11	1.01	2.24
BRA	15.20	6.14	17.52	12.40	9.22	23.05	5.09	2.64	5.71	13.16	2.21	0.64	0.89	3.05	6.34	3.20	3.66	5.77	0.89
CHL	3.79	20.67	15.23	5.47	2.53	3.18	4.48	6.34	8.41	12.29	3.29	0.13	3.02	3.39	8.02	6.85	2.04	0.77	0.87
XSM	18.40	21.55	19.53	13.47	9.41	8.24	5.27	10.47	9.06	12.11	5.86	0.42	4.41	4.99	6.87	2.63	5.89	7.82	0.91
EUEFTA	8.36	10.16	8.19	10.91	19.58	11.49	4.27	1.76	3.71	4.22	0.87	0.10	0.55	1.21	1.72	3.69	1.65	1.16	0.43
XER	5.07	10.22	32.19	7.43	4.65	9.48	23.00	15.85	16.54	15.54	1.32	2.02	4.63	4.47	3.95	3.90	3.59	2.89	6.20
FrmUSSR	11.75	28.10	25.04	24.91	6.97	10.14	11.67	8.97	9.29	13.47	2.81	1.66	3.85	3.95	4.80	2.71	3.41	3.22	4.75
MENA	0.77	13.32	12.21	16.40	8.11	8.88	4.73	4.26	8.51	6.10	5.76	0.28	1.42	4.42	3.45	1.08	0.98	2.34	1.46
ZAF	5.23	5.73	7.45	4.95	15.96	7.18	4.27	5.86	10.25	4.92	1.75	0.08	1.84	6.06	2.22	3.40	1.03	0.85	0.55
MWI	5.53	6.13	10.07	6.55	15.00	7.31	3.95	21.18	28.13	23.29	7.74	4.88	1.52	8.90	10.53	2.80	2.48	3.10	2.28
MOZ	4.51	6.25	9.54	4.89	5.59	7.07	14.07	5.30	18.84	11.42	7.80	0.21	1.14	12.08	8.94	2.26	4.36	1.76	2.00
TZA	30.79	7.05	10.45	17.82	10.97	7.27	18.81	7.55	17.89	12.58	6.22	2.28	3.82	1.67	1.60	10.75	30.26	7.04	2.67
ZMB	22.41	6.15	7.94	6.48	10.10	7.73	5.65	11.42	15.49	5.37	2.28	0.27	0.69	4.03	2.38	6.58	1.32	1.72	0.51
UGA	25.69	32.66	18.39	14.25	14.55	6.51	3.89	13.16	13.22	13.38	11.24	1.37	2.64	6.19	7.09	7.95	3.17	7.91	2.98
XSS	11.89	16.34	13.09	5.29	4.14	8.77	3.80	5.70	4.86	5.85	2.79	0.31	0.46	2.31	1.95	1.87	5.94	1.29	0.70

example, primary agriculture is 5.7 percent of the total cost of production in the U.S.[12] Australia had some of the largest time-series residuals; however, their commodity price variation is lower than most other regions. Rather, many of the developing regions (e.g., India, African regions, and Former Soviet Union) have some of the highest values of price variation.

The next step is to see how export taxes contribute to commodity price variation. To do so, we use the same database (now set to 2008) and the same production shocks, but we couple them with an arbitrary increase in export taxes of 25 percent across all commodities. Table 8 presents the results of this experiment. To isolate the impacts from export taxes, we subtract out the production volatility. The results indicate that export taxes do not lead to much commodity price variation, save for a few commodities in certain regions. Indeed, most of the standard deviation differences are less than 1 (or are zero); however, Australia and New Zealand (AUSNZL), Indonesia (IDN), and Rest of South America (XSM) have differences greater than 1. These are also the regions that tended to have export taxes in place in the base model; adding a 25 percent increase leads to sizeable commodity price variation. The commodities that have a standard deviation greater than 1 from export taxes includes: coarse grains (crsgrns) 3 times, oil seeds (oilseeds) 4 times, other crops (othcrps), milk and beef (two times each), preprocessed sugar, rice, and oil seeds (once each).[13] Since there are 34 regions in the model, we can conclude that export taxes do slightly impact commodity price variation for some commodities in some regions.

[12] Further information on the transmission of primary commodity volatility to secondary products is pointed out in the Food Dollar series from the Economic Research Service, which notes that the farm share was 15.6 cents of each food dollar expenditure.
[13] Several sectors have no change in price.

Table 8. Model-generated commodity price variation based on export taxes

	Rice	Wheat	Crsgrns	Oilseeds	Sugar	Cotton	OthCrps	Milk	Cattle	NRumin	Fish	Forest	PrDairy	PrBeef	PrNRumn	PrSugar	PrRice	PrOilsd	OthFdBev
AUSNZL	1.67	0.02	0.79	0.03	0.54	0.10	2.43	2.19	0.19	0.13	0.01	0.12	0.44	3.03	1.00	0.06	1.34	1.13	0.02
CHN	0	0	0	0.12	0.23	0.09	0.78	0	0.07	0.04	0	0.10	0.05	0.02	0.03	0.05	0.01	0.07	0.01
JPN	0.09	0	0	0.08	0.01	0.04	0.01	0.31	0.08	0.10	0.01	0.13	0	0.01	0.05	0.01	0.04	0.04	0.01
DVDASIA	0.03	0	0	0.09	0.01	0.04	0	0.30	0.08	0.15	0	0.13	0	0.02	0.04	0.01	0	0.01	0
IDN	0.01	0.03	1.36	3.10	0	-0.02	0.10	0	0.02	0.52	0	0.05	0	0	0	0.02	0	0.01	0.01
PHL	0.19	0	0.02	0.02	0.11	0.01	0.26	0.07	0.03	0.01	0	0.02	0.01	0.40	0.07	0.01	0.02	0.05	0
THA	0.30	-0.02	0.25	0.06	0.64	0.17	0.10	6.95	0.07	0.05	0	0.01	0.21	0.13	0.11	0.02	0.06	0.02	0.03
VNM	0.20	0.01	0.22	0.36	0.03	0.01	0.08	0.02	0.19	0.01	0.01	0.02	0.41	0.10	0.03	0.02	0.01	0.02	0.02
XSE	0.12	0.10	0.08	1.44	0.04	0.19	0.05	0.02	0.12	0.01	0	0.47	0.09	0.05	0.07	0.03	0.02	0.02	0.01
BGD	0.04	0	0.02	-0.01	0.06	0	0.07	0.08	0.01	0	0.01	0.01	0.02	0.82	0.04	0.03	0.04	0.10	0.01
IND	0.23	0.01	0.02	0.03	0.05	0.01	0.04	0.14	0.05	-0.01	0.04	0.04	0.01	0.01	0.03	0.01	0.03	0.02	0
PAK	0.15	0.01	0.12	0.01	0.08	0.08	0.29	0.80	0.03	0.01	0.01	0.03	0.12	0.26	0.04	0.11	0.44	0.28	0.01
XSA	0.06	0.01	0.43	0.20	0.02	0.01	0.03	0.37	0.06	0.01	0	0.01	0.01	0.22	0.01	0.03	0.08	0.10	0
CAN	0.06	0.01	1.15	0.18	0.02	0.06	0.09	0.06	0.29	0.01	0.01	0.01	0	0.17	0.01	0.04	0.05	0.06	0
USA	0.23	0.02	0.11	0.34	0.02	0	0.04	0.02	0.11	0.16	0.01	0.03	0.01	0.10	0	0.01	0.01	0.04	0.01
MEX	0	0.03	0.23	0.85	0.01	-0.01	0.03	0.14	0.15	0.28	0	0.07	0	0.01	0.01	0.16	0.01	0.18	0.01
XCA	0.01	0.01	0	0.08	0.01	0.01	0	0.23	0.01	0.13	0	0.12	0	0	0.03	0.03	0.13	0.01	0
COL	0.02	0.03	0.11	0.11	0.01	0.05	0.01	0	0.01	0.03	0.01	0.02	0.01	0.06	0	0.09	0.01	0.01	0
PER	0.02	0.01	0.46	0.25	0.08	0.02	0.01	0.52	0.21	0.08	0.04	0.04	0.01	0.05	0.03	0.04	0	0.02	0.01
VEN	0.02	0.03	0.14	0.29	0.01	0.01	0.02	0	0.10	0.11	0.01	0.02	0.01	0.04	0.03	0	0	0.02	0.01
BRA	0.01	0.01	0.01	0	0.03	0	0.03	0.03	0.02	0.01	0	0.03	0.01	0	0.01	0.08	0.10	0.36	0.01
CHL	0	0	0.01	0	0.09	0.02	0.22	0.07	0.10	0.01	0	0.03	0.02	2.12	0	0.01	0.83	0.44	1.96
XSM	0.07	0.31	4.42	4.96	0.01	0.03	1.10	0.28	0.41	0.47	0	0.31	0.01	0.54	0.01	4.21	0.03	0.34	0.01
EUEFTA	0.03	0.03	0.46	1.77	0.04	0.23	0.02	0.06	0.23	0.37	0.01	0.03	0.02	0.14	0.05	0.48	0.39	0.20	0.34
XER	0.04	0.03	0.03	0.36	0.30	0.03	0.38	0.16	0.21	0.12	0.05	0.10	0.02	0.12	0.02	0.01	0.02	0.06	0.01
FrmUSSR	0.05	0	0	0.01	0.01	0.01	0.01	0.08	0.03	0.08	0	0.05	0	0.01	0.04	0.01	0.01	0.02	0
MENA	0.06	0	0	0	0.01	0.01	0.02	0.09	0	0.08	0	0.05	0	0	0.05	0.02	0.02	0.02	0
ZAF	0.06	0	0	0.01	0.01	0	0	0.07	0.01	0.08	0	0.05	0	0	0.04	0.01	0.01	0.02	0
MWI	0.07	0	0	0.01	0	0.01	0	0.13	0.01	0.08	0	0.05	0	0	0.04	0.01	0.02	0.02	0
MOZ	0.06	0	0.01	0.01	0.01	0.02	0.01	0.16	0.02	0.08	0	0.12	0	0.01	0.05	0.01	0.05	0.04	0.08
TZA	0.05	0	0	0.03	0.01	0.01	0	0.05	0	0.09	0	0.05	0	0.01	0.04	0	0.02	0.02	0
ZMB	0.07	0	0	0.06	0.01	0.02	0.02	0.21	0.02	0.10	0	0.10	0	0.01	0.05	0.01	0.02	0.02	0
UGA	0.08	0	0	0.05	0.02	0.03	0.03	0.25	0.02	0.10	0	0.10	0	0.01	0.05	0.01	0.02	0.04	0
XSS	0.07	0	0	0.06	0	0.02	0.01	0.12	0.04	0.09	0	0.05	0	0	0.04	0.01	0.01	0.02	0.01

We can also examine the impacts to poverty from the production volatility and export tax shocks. Table 9 indicates that poverty is not actually affected much from the production volatility shocks. Only Brazil and Indonesia have a standard deviation of greater than 1. When we add the increase in export taxes to the production volatility, we get some slight change in the results. Like the other results for export taxes, the biggest change when adding export tax changes to production volatility is in Indonesia.

Table 9. Standard deviation change in poverty

	Production volatility		Production volatility with export taxes	
	Below $1.25/day	Below $2/day	Below $1.25/day	Below $2/day
BGD	0.68	0.46	0.70	0.48
BRA	0.40	1.49	0.43	1.56
CHL	0.01	0.04	0.01	0.04
COL	0.04	0.52	0.04	0.60
IDN	0.71	1.34	0.84	1.56
MWI	0.06	0.05	0.10	0.07
MEX	0.13	0.15	0.15	0.20
MOZ	0.08	0.05	0.08	0.05
PER	0.08	0.06	0.08	0.07
PHL	0.51	0.49	0.54	0.55
THA	0.04	0.25	0.06	0.45
VEN	0.07	0.10	0.07	0.10
VNM	0.04	0.29	0.04	0.30
ZMB	0.06	0.01	0.06	0.01

4.6 Impacts of removing export taxes

The final piece of this CGE work examines the global impacts of removing export taxes. That is, we start with the 2008 model and remove export taxes (there are no other changes to the model, such as to export subsidies or baseline changes). To investigate how removing export taxes might alter agricultural markets, we look at changes to production, prices, trade, and poverty. Table 10 shows the export taxes in place in 2008, for those regions which had those barriers in place. Several regions had no export taxes in 2008.[14] Of those regions that did have export taxes, most were less than 10 percent of the value of exports, and most regions that did apply exports taxes had them on only a handful of commodities. The exceptions are: China (Chn), Vietnam (Vnm), Rest of South America (XSM), and the former USSR (FrmUSSR). Our analysis breaks the world into two parts: those which had export taxes (exptax) and those which did not (others).[15]

Table 10. Export taxes in place in 2008

	CHN	IDN	VNM	XSE	PAK	XSA	XCA	XSM	FrmUSSR	MENA	ZMB	XSS
Rice	4.83		3.00					0.35		0.98		
Wheat	18.60							6.26	15.00			
Crsgrns	5.31		2.11					6.44	6.52			
Oilseeds	1.80	12.82				0.49		6.65	15.00		11.32	
Sugar												
Cotton								3.34			13.73	
OthCrps			1.49		1.86	10.82	0.25	1.95				1.25
Milk								5.59				
Cattle							3.88	4.76	1.26			
NRumin			10.49		0.20			3.78	0.27			
Fish												
Forest		6.03	1.72					2.34				
PrDairy								5.59				
PrBeef								6.27				
PrNRumn								3.05				
PrSugar					2.33							
PrRice	4.83		3.00			0.62		4.79		0.93		
PrOilsd	0.18	8.97		0.33		0.27		9.83	0.25			
OthFdBev	0.08		0.01		0.33			0.91	0.38			0.79

[14] Japan (JPN), Korea and Taiwan (DVDASIA), Philippines (PHL), Thailand (THA), Bangladesh (BGD), India (IND), Canada (CAN), United States (USA), Mexico (MEX), Brazil (BRA), Colombia (COL), Peru (Per), Venezuela (VEN), EU-EFTA (EUEFTA), Rest of Europe (XER), South Africa (ZAF), Malawi (MWI), Mozambique (MOZ), Tanzania (TZA), Uganda (UGA). Australia/New Zealand (AUSNZL) had a very small (0.001 percent) tax on wheat. We assume that this is essentially zero in our model.

[15] We aggregate into these two parts by taking a weighted share of each result. We also mention the main region that drives each result, especially for the export tax group.

Table 11 presents the results across all agricultural commodities. First, looking at production changes, the results indicate the largest increases in production are to the commodities that tended to have the largest export taxes in place: wheat and oilseeds (raw and processed). China had a sizeable export tax for wheat, its change in production is 0.59 percent. Former USSR also had an increase in wheat production (5.07 percent). For raw oilseeds, the increase in production is driven by Indonesia (8.07 percent) and the Rest of South America (7.72 percent). Both of these regions have quite large industries in the baseline. The increase in oilseeds production, combined with a fall in export taxes applied to processed oilseeds, leads to an increase in processed oilseeds production (PrOilsd). This result suggests that these regions are choosing to crush their own oilseeds rather than exporting the raw product.[16] Processed oilseeds had export taxes in place across several regions, but they tended to be of a smaller magnitude than those for oilseeds.[17]

The increase in production for those commodities subject to export taxes draws resources (land, labor, capital) away from other commodities. Thus, we see a small decrease in production for several commodities in the ExpTax group that did not have export taxes in place. The Others group has changes in production that essentially mirror those of the ExpTax group. There is a decrease in wheat, oilseeds, and processed oilseeds production (production in Canada and the U.S. is harmed substantially compared to the others), but there is a small increase in production in some other commodities. In particular, there are increases in some of the livestock categories (the percentage changes are small, but these are very big sectors in the baseline), indicating that many regions in the

[16] This point is further made by noting that the change in exports of processed oilseeds (12.27 percent) is greater than the change in exports of oilseeds (5.62 percent).
[17] This phenomenon is known as Differential Export Taxes: some countries choose to apply lower export taxes along the production chain in order to promote production of higher value added products. Our results indicate that the removal of export taxes would have the same effect: higher production and exports of produced oilseeds than of oilseeds. However, we should be cautious when analyzing this result, as we are not including the full production chain. The result for the Rest of South America (XSM) is mainly explained by Argentina, which has a larger export tax in the baseline on Produced oilseeds (9.83) than on Oilseeds (6.65).

Others group shift land to livestock production. For example, the U.S. has a decrease in crop production (rice, wheat, coarse grains, oilseeds, sugar, cotton, other crops) of -0.20 percent, and an increase in livestock production (milk, cattle, nonruminants) of 0.01 percent. Because U.S. crop production has a slightly higher value than livestock, this result indicates that removing export taxes hurts regions that compete with those who previously had export taxes.

Table 11. Model results for removing export taxes

	Production		Market Price		Exports		Imports	
	ExpTax	Others	ExpTax	Others	ExpTax	Others	ExpTax	Others
Rice	-0.02	-0.11	0.55	-0.67	0.59	-0.06	0.36	1.81
Wheat	1.28	-1.17	0.11	-0.01	35.63	-3.68	5.37	1.22
Crsgrns	0.38	-0.20	0.06	0.00	5.89	-0.95	0.65	0.35
Oilseeds	2.51	-0.81	0.06	-0.01	6.66	-1.46	0.92	0.01
Sugar	-0.07	0.11	-0.01	0.06	-0.55	0.26	0.05	-0.21
Cotton	-0.07	0.08	0.25	-0.20	-0.25	0.19	-0.02	0.03
OthCrps	0.01	0.03	0.39	-0.36	1.16	-0.05	0.99	0.14
Milk	0.14	0.00	0.36	-0.19	-0.47	0.53	1.45	-0.17
Cattle	0.12	-0.05	1.26	-0.39	0.94	-0.10	0.08	-0.02
NRumin	0.03	0.03	0.18	-0.12	0.27	0.02	0.18	0.02
Fish	0.00	0.03	0.05	-0.15	0.24	-0.01	-0.05	0.05
Forest	0.01	-0.04	0.18	-0.17	0.88	-0.29	0.65	0.19
PrDairy	0.07	-0.01	0.29	-0.16	5.13	-0.15	0.24	0.24
PrBeef	0.17	-0.06	0.41	-0.17	10.76	-0.50	0.68	0.47
PrNRumn	-0.16	0.05	0.08	-0.14	-0.17	0.16	0.43	0.03
PrSugar	0.02	0.09	-0.01	0.08	-0.28	0.28	0.21	-0.05
PrRice	0.07	-0.13	0.06	-0.03	6.86	-1.85	0.98	1.66
PrOilsd	1.51	-0.93	0.24	-0.06	12.51	-4.36	3.86	3.67
OthFdBev	0.02	0.04	0.51	-0.08	0.12	0.06	0.20	0.03

Market prices increase for almost all commodities in the ExpTax region as there is now more competition for these commodities (i.e., domestic versus export uses). Prices tend to rise higher for those commodities that had the largest production increases. The opposite occurs in the Others category, as more commodities on the global market means more imports and lower domestic prices. The biggest increase in exports (by magnitude) is to wheat for the ExpTax group. China is a small wheat exporter, but the Former USSR is a large exporter. Exports in those two regions increase by 266.87 and 143.67 percent.

One question concerning the removal of export taxes is what happens to the commodity when the tax is removed. Does production increases, and if so, does that production get used domestically or is it exported? Our model reports the amount of a commodity sold domestically (results are available upon request from the authors). The Former USSR actually has a decrease in domestic sales of wheat (-1.66 percent). Thus, it is clear that they are essentially exporting all their new production of wheat. There are increases in exports for other commodities (notably oilseeds and processed oilseeds) for the ExpTax group, and similar decreases for the Others group. Along with the U.S. and Canada, Brazilian exports are also hurt in this scenario, as they often compete with regions in the ExpTax group (in particular, Argentina).

Interestingly, the ExpTax group have increases in imports for many commodities, especially those in which they had big export gains. Some of this is trade with each other (e.g., China is the world's largest importer of oilseeds and processed oilseeds). But some of this is exports displacing domestic consumption, hence the need for imports. For example, although they are not a very importer of wheat, the Former USSR has an increase in wheat imports of 63.47 percent in this scenario.

Finally, we examine how removing export taxes impacts poverty. Two pieces of information that will be useful in understanding changes to poverty are the share of poverty in each strata[18] and the share of imports in food consumption for each region. This information is given in table 12 for those regions with detailed poverty information from Hertel et al. (2015). The share of poverty in agriculture is useful in understanding how the

[18] Along with agricultural self-employment, the other strata (or sub-populations) are: non-agricultural self-employment, rural wage labor, urban wage labor, transfer payments, rural and urban diversified.

reduction in production could impact various regions. Of course, those employed in agriculture could actually be better suited to weathering the production reduction and export tax increase, as the other strata are demanders of food. To provide a flavor of that aspect, the second column of data provides information on the share of imports in food consumption: those with a greater percentage will likely be impacted by the removal of export taxes.

Table 12. Strata information and the share of imports in food consumption

	Share of poverty in agriculture (%)	Share of imports in food consumption (%)
BGD	15	5.56
BRA	1	3.54
CHL	0	6.53
COL	10	6.51
IDN	42	7.11
MWI	54	10.74
MEX	9	3.20
MOZ	41	21.18
PER	31	5.98
PHL	11	7.73
THA	6	17.57
VEN	8	1.56
VNM	4	23.84
ZMB	34	8.46

Source: Share of poverty in agriculture is from Hertel et al. (2015); the share of imports in food consumption is from the GTAP-POV database.

Table 13 presents information on the changes in poverty for those regions with detailed information by strata. The results across all strata indicate that poverty does not change by much across both types ($1.25/day and $2/day) in all regions if export taxes are removed. The only region that has a meaningful impact (greater than a tenth of a percent) is Indonesia (IDN), which, along with Vietnam, is the only region that was included in the

ExpTax scenario. Vietnam (VNM) had the second largest decrease in poverty.[19] This result shows that policies that isolate domestic prices are not necessarily effective in protecting the poorest population, not even in the agriculture strata, as poverty in Indonesia also falls among this strata. Among some countries that do not change export taxes, poverty increases slightly, which could be explained by the increased competition in agricultural markets of products such as wheat, oilseeds and produced oilseeds.

Table 13. Percent change in poverty levels by region

	Across all Stratas		Agriculture Strata	
	Below $1.25/day	Below $2/day	Below $1.25/day	Below $2/day
BGD	-0.03	-0.02	0.01	0
BRA	0.01	0.02	0.01	0.01
CHL	0	0	0	0
COL	0	-0.01	0	0.01
IDN	-0.07	-0.14	-0.02	-0.01
MWI	0	0	0	0
MEX	0	0	0	0
MOZ	0	0	0	0
PER	0	0	0	0
PHL	0	0.01	0	0
THA	0	0.02	0	0
VEN	0	0	0	0
VNM	0	-0.07	0	-0.01
ZMB	0	0	0	0

5. Conclusions

Most major types of trade barriers on agricultural products have been reduced since the formation of the World Trade Organization. Globally, tariffs have been reduced, export subsidies are scheduled to be eliminated, and the Trade Facilitation Agreement holds some promise on addressing non-tariff measures. However, export restrictions, such as export

[19] These changes in poverty might seem small, but the model does not naturally generate big changes in poverty. For example, the research introducing this model has changes in poverty of only -0.19 percent under the proposed Doha tariff liberalization scenario.

taxes have remained prolific, andin fact, have been increasing in number over the last ten years. Perhaps it is because they are only used by a subset of countries or commodities, but export taxes have not received the same scrutiny in multilateral trade negotiations as other trade barriers. This is despite the fact that export taxes often occur when food prices are high and/or volatile. While export taxes have received attention in the academic literature, these studies tend to examine only a single commodity or country.

Our work seeks to provide more a detailed investigation of the linkages between export taxes, trade, and food prices. To do so, we utilize both a partial equilibrium-econometric framework, and a global general equilibrium model, which, in tandem, capture different aspects of these linkages. Our results show that export taxes applied during the food crisis had a positive effect on world prices of some agricultural commodities. This result is validated by both models, although the commodities affected vary in each methodology. This could be explained by the fact that the time frame applied is not the same. Our results also show that removing export taxes in place in 2008 would benefit certain regions (those that have export taxes in place), but hurt countries competing for these countries' exports. The overall impact on global prices is not significant, and the impact on poverty is also slight, with some reduction of poverty in countries that had export taxes in place in the baseline. Our approach shows that the general equilibrium effects of trade barriers such as export taxes are significant and should be considered when discussing the removal of such barriers.

In this paper, we only investigate the linkages between export taxes, trade, and prices. However, there are several other export barriers that could be examined in future research. Some examples include export bans, export license requirements, and price reference for exports. While Estrades et al. (2017) indicate that they are not as numerous as export taxes, they could have different impacts that could affect trade and prices. For example, export taxes only apply a surcharge to any exports; however, an export ban completely prohibits any of the product from leaving the country. It is likely that such a drastic measure would have different impacts from export taxes.

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Appendix 1. Regional and Sectoral Mapping of the CGE Model

Regions		*Sectors*	
Short Name	Description	String	String
AUSNZL	Australia + New Zealand	Rice	Rice
CHN	China	Wheat	Wheat
JPN	Japan	Crsgrns	Coarse Grains
DVDASIA	Korea + Taiwan	Oilseeds	Oilseeds
IDN*	Indonesia	Sugar	Sugar
PHL*	Philippines	Cotton	Cotton
THA*	Thailand	OthCrps	V_F, Other crops
VNM*	Vietnam	Milk	Dairy Farms
XSE	Rest of South + East Asia	Cattle	Ruminant (Other than dairy)
BGD*	Bangladesh	NRumin	Non Ruminants
IND	India	Fish	Fisheries
PAK	Pakistan	Forest	Forestry
XSA	Rest of South Asia	PrDairy	Dairy Products
CAN	Canada	PrBeef	Processed Ruminants
USA	United States	PrNRumn	Processed Non Ruminants
MEX*	Mexico	PrSugar	Refined Sugar
XCA	Rest of Central Am + Carrib	PrRice	Processed Rice
COL*	Colombia	PrOilsd	Vegetable Oils and Fats
PER*	Peru	OthFdBev	Other food, beverages, tobacco
VEN*	Venezuela	TextAppl	Textiles, Apparel and Footwear
BRA*	Brazil	Autos	Autos and parts
CHL*	Chile	HvyMnfcs	Heavy industry
XSM	Rest of South America	Electron	Electronic equipment
EUEFTA	The European Union + EFTA	OthMnfcs	Other Manufactures
XER	Rest of Europe	WRtrade	Wholesale/Retail Trade
FrmUSSR	Former Soviet Union	TransCom	Transport, Communication
MENA	MENA	FinSvce	Financial and business serv
ZAF	South Africa	HsEdHe	Housing, educ, health, public
MWI*	Malawi	Utility	Uitlities
MOZ*	Mozambique	Petrol	Petroleum
TZA	Tanzania	Constrct	Construction
ZMB*	Zambia		
UGA	Uganda		
XSS	Rest of Sub-Saharan Africa		

* indicates a region that has poverty information

Note: Our results only focus on agricultural sectors. Results for the non-agricultural sectors are available upon request.