Endogenous Adoption of International Agri-food Practices and Standards

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Abstract: Countries around the world carry very diverse sets of rules and practices when it comes to the regulation of agriculture. These differences stem from varying degrees of concern or perceived risk for food safety, animal and plant health concerns, and environmental protections and further the legacy of different regulatory traditions. Differences in standards across borders can in turn lead to sources of contention between trading partners. With growing concerns for climate change and increasing demand for food standards, major food systems are heading into different directions. Further, given the economic importance of market access and heterogeneity in demands for regulations across regions, production practices and standards by major global producers evolving under different spheres of influences. This study examines the adoption of international agri-food practices in the context of economic welfare tradeoffs between market access and costs of adoption, using the case of the EU's Farm to Fork and Biodiversity Strategies. We introduce a modeling technique in our economic framework that endogenously determines a country's decision to adopt the EU's farm to fork program. We present results based on if the benefits from joining (keeping trade markets open with other adopters, but enduring higher production costs) are greater than the benefits from not joining (closed trade markets, but no change in production costs). In addition, we use the recent departure of the UK from the EU to examine if the reduced size of the EU might affect other countries from participating in their policy.

The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy. This research was supported [in part] by the U.S. Department of Agriculture, Economic Research Service.

Introduction

Agricultural and food production practices throughout the world vary according to socio-political and physical environments. Accordingly, alternative environments, production processes and standards are associated with differences in agricultural and food output globally.[1] As such, standards are used to safeguard the integrity of production environments and human health (e.g., disease pathogens). Restrictions in the movement of raw agricultural products are justified within (e.g., Hawaii and continental U.S.) and between countries. The Codex system, implemented in 1963, offers a multilateral approach to generating these standards to mitigate concerns over arbitrary rules to limit trade, i.e., protectionism. Most of the world (189 countries, with the European Union (EU-27) counted as a single entity) has adopted the Codex system of internationally recognized standards, codes of practice, and guidelines related to foods, food production, and food safety. However, Codex compliance is voluntary and does not have a binding effect on national food legislation,[2] and further development of Codex standards may suffer delays (Wieck and Grant, 2021).

In the short-term, countries may impose trade barriers in the form of new standards that have not been incorporated into Codex. These non-tariff measures (NTMs) that can restrict trade are often framed as sanitary and phystosanitary standards (SPS) related to production and processing (e.g., pathogens and chemical residues). Trade partners may dispute country-specific standards on the grounds of protectionism through the World Trade Organization (WTO), but this is a lengthy process that may take several years, meanwhile trade remains restricted. In the short-term, trade partners are forced to choose between trade being shut off (subject to the cost of diverting trade to other markets) or conforming to the new standards (subject to the cost of compliance). Thus, to trade or not to trade, that is the question this paper addresses.

The decision on whether to divert trade to other markets or conform to the importing county's standards to retain market share is often dictated by the size of each participating country. Conforming to the importing country's new standards means that the exporting country can shift resources as needed — essentially creating a new sub-industry for the product category, which can range substantially in scope from specific products (e.g., chicken) to more broadly defined characteristics (e.g. aflatoxin) that can affect multiple raw commodities and processed goods. Meeting new standards in the short-term is often limited to 'big' countries, in the classical big/small country comparisons in the trade literature, or those with high value and highly specialized export-oriented production (e.g., coffee and cacao). Whether 'big' or highly specialized, sizeable export demand is an important condition to justify establishment of a sub-industry to meet new standards. A prominent example of this is U.S. beef exports to the EU, where the EU prohibits beef from cattle that receive supplemental growth hormone (i.e., ractopamine). As such, the U.S. created the non-hormone treated cattle (NHTC) program. Beckman et al. (2020a) estimate that the mean additional cost to meet the EU standard is 125 percent greater than the cost of producing cattle for the domestic market. Yet, this additional cost is justified because of favorable trade conditions under allotted tariff-rate quotas (TRQs) that are filled in most years (Beckman and Arita 2016). On the other hand, EU standards for other animal products (e.g., pork and chicken) have not been resolved through the creation of a new sub-sector, and instead trade in these products has remained cut off (Arita et al. 2014).

The work here tries to quantify which countries might create new industries to go along with another country's standards. This 'self-selection' has been noted as creating biases when using a gravity model,[3] but it is important to understand which countries might alter their production systems to comply—given that this could impact global agriculture. As such, we construct a method to allow a computable general equilibrium (CGE) to endogenously determine which countries might self-select into making the change. CGE models are often used to estimate the impacts of trade agreements, including information on self-selection that could provide policymakers additional metrics on the potential impacts of adopting or setting standards. As an example, we examine the EU's Farm to Fork and Biodiversity Strategies (henceforth referred to as 'Strategies') to determine who might follow them in adopting the policy. These Strategies propose to reduce the amount of inputs used in agricultural production, which represents a fundamental shift in the EU food and agriculture industry and has, therefore, been the subject of wide debate (Schebesta and Candel, 2020). The proposal also pledges to use trade policies and other international efforts to support this vision of sustainable agri-food systems, suggesting intentions to expand the reach of the policy beyond the EU. Beckman et al. (2020b) previously provided an analysis of the potential impacts from the EU, and other regions adopting the Strategies; but their work assumes that multiple countries dependent on the EU as an agricultural market for their exports adopt the strategies.

Ultimately, our work sheds light on the decisions that countries face when presented with an NTM on their exports, having the model estimate their adoption criterion based on whether the net benefit of participation (maintaining open trade with EU and other participants, under higher production costs) outweighs the net benefit of non-participation (restricted trade with EU, under constant production costs). We compare these results with those from the most similar 'middle' scenario in the Beckman et al. (2020b) analysis of the Strategies. In addition, we use the recent departure of the UK from the EU to examine how reduction in EU size might affect other countries decision to participate in the Strategies.

Farm to Fork and Biodiversity Strategies

The European Commission (EC) unveiled its Farm to Fork and Biodiversity Strategies in May 2020 with the stated goal to foster greater sustainability in EU food and agricultural systems. In order to achieve this aim, the initial version of the Strategies would impose restrictions on European Union (EU) agriculture through targeted reductions in the use of land, fertilizers, and pesticides. The proposal includes specific reductions of agricultural land (10 percent), fertilizers (20 percent), pesticide use and risk (50 percent), and antimicrobials (50 percent). More generally, the Strategies take a broad approach to promoting sustainability in agriculture in four areas for improvement. These include (1) sustainable food production, (2) sustainable food consumption, (3) sustainable food processing and distribution, and (4) food loss and waste prevention. Setting policy targets for 2030, the Strategies focus on EU agricultural sector stewardship of the environment, as well as food security and human health outcomes. Ultimately, the Strategies' proposal represents a fundamental shift in the EU food and agriculture industry and has, therefore, been the subject of wide debate (Schebesta and Candel, 2020).

Methodology

Computable General Equilibrium (CGE) models are often used to evaluate the potential policy impacts, as they provide economy-wide and commodity-specific effects while considering inter-industry linkages. Another benefit of the CGE model is that it captures the economic effects of regulations related to land being taken out of use. For this work we use a specific CGE model, the Global Trade Analysis Project – Agro-Ecological Zones (GTAP-AEZ) model, which divides the world into 18 agroecological zones, and explicitly accounts for land use by allowing cropland to compete with other land applications. We assume a medium-run horizon; thus, the results are interpreted as the impacts that occur over 8–10 years.

The latest GTAP database is set to 2014. Given that the EU Strategies are in reference to changes from 2020, we follow Beckman et al. (2020b) and update the database using inputs to the model for GDP, population, labor, capital, and productivity. The GTAP database has 65 sectors and 141 regions, which can be aggregated into broader categories. There are 20 agricultural commodities in the database which are kept mostly disaggregated in this simulation (appendix table A-1). However, commodities vital to this work (fertilizers, pesticides, and antimicrobials) are aggregated into larger sectors in the original GTAP database. To model these properly, we split these from their aggregated sector (known as “chemicals”). To do so, we say that any chemicals used in agriculture are either fertilizer, pesticides, or antimicrobials, we then use FAO data to split this category into the three types of chemicals.

To incorporate the impact of the Strategies in the model, all the agricultural input reductions are conducted simultaneously. They are applied as a reduction in each targeted value across the entire primary agriculture sector (e.g., we target a reduction in fertilizer use by 20 percent for all crops). This approach allows the model to solve for the most economically efficient use of the components while still reaching the policy target. To achieve the required reductions in inputs fertilizer, pesticide and antimicrobial use, we introduce a tax on their use which brings the total use to the application level set by the Strategies. To reduce land use across 18 agroecological zones (AEZs), we adjust the available area by land type so the returns to each type of land are constant and the total area is reduced by the desired percentage. To minimize distortions from policy-related government revenue, we distribute all tax revenue generated by the input taxes back to producers in the form of a uniform tax reduction on farm output.

Previously, Beckman et al. (2020b) estimated participation in the Strategies for 3 scenarios; 1) if the EU was the only region to participate; 2) if countries with greater dependence EU markets for agricultural exports also participated in the Strategies, and; 3) worldwide participation. Our work here, focuses on the 2nd scenario from this earlier work, the so-called ‘middle’ scenario. This scenario assumes certain countries join in the EU in adopting the input reductions from the Strategies, such an approach (using alternative assumptions) is common in ex-ante estimation of CGE models (since a country’s decision to participate is unknown). We compare the results of the earlier study with the self-selection criteria that we impose in this work. The differences between the earlier ‘middle’ scenario and self-selection model presented in this paper provide insights into modeling trade policies and NTMs and the sensitivity of estimates to alternative participation criteria.

Endogenous selection

To determine what regions might join the EU in adopting the Strategies, we design an algorithm in the CGE model that is in the spirit of game theory and a Nash equilibrium. That is, we run the model for each region (there are 141 regions in the version 10, GTAP database-excluding the EU 27, the model is conducted for the remaining 114 regions), with iterations based on whether or not the region participates in the Strategies. The decision is based on a comparison of welfare (the model uses equivalent variation)[4] for the regions based on the participation decision (Y/N) for the Strategies. Similar to Beckman et al. (2020b), regions that participate have to reduce inputs according to the proportions specified in the Strategies, those that do not, face a reduction in exports to the participant regions by 50 percent (implemented as an NTM).[5] Beckman et al. (2020a) provide evidence that the mechanism to implement the NTM in a CGE model matters, and that specifying it as a tariff is less distorting. In addition, it is in-line with the behavior of our scenario, since the NTM is being placed on imports from non-participant regions.

The algorithm worked like this: In the first iteration, a region decides if it wants to join the EU in adopting the Strategies such that if: $EV_{Strategies} > EV_{NTM}$ it will participate. The algorithm solves this equation for every region in the model and collects information on which regions participate. In all subsequent iterations, a region decides if it wants to join the EU and other participants in adopting the Strategies such that (again) if: $EV_{Strategies} > EV_{NTM}$. The Nash equilibrium concept is introduced here in that all regions in the subsequent iterations know what each other is doing—hence they make a participation decision. Countries again make their decisions (going back to step 1), the model concludes at the point when no country benefits by changing their participation decision.

Results

The results of our simulation suggest that several countries and regions would find that joining the Strategies and preventing the NTMs from the EU would result in greater welfare. These countries are shown in Figure 1 in orange. While they include many of the countries envisioned to join based on their high agricultural export share to the EU under the middle scenario (Beckman, et al. 2020), we find that some of the countries would not join (e.g., Norway, Switzerland, and many countries in Africa) while several countries in Latin America and Asia would join (e.g., Argentina, Chile, Paraguay, Ecuador, and Laos).

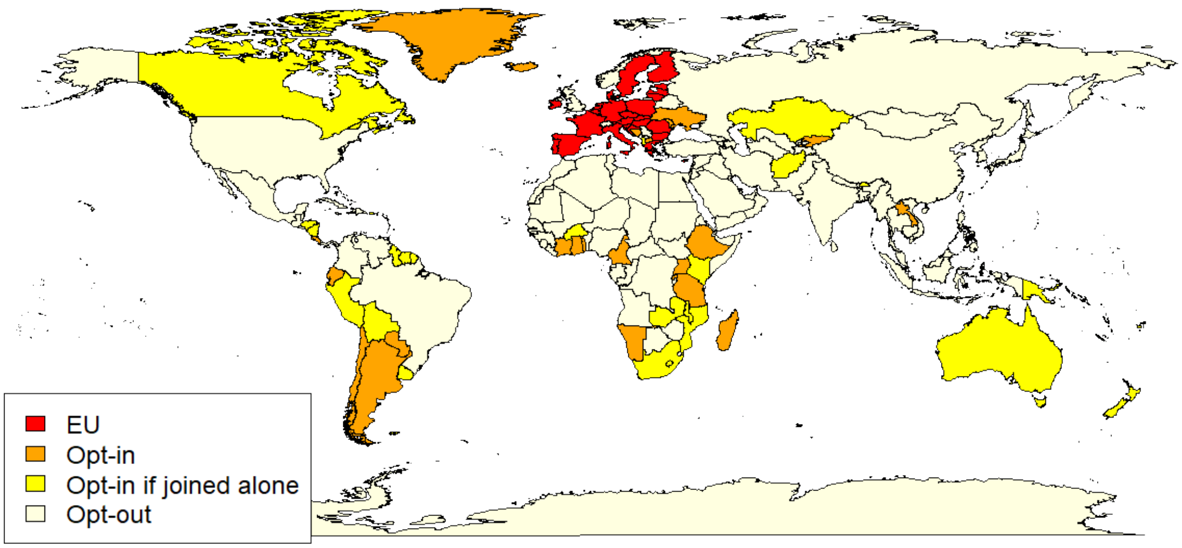

Figure 1: Participation in the EU's Farm-to-fork strategies

In addition to the countries that would join, Figure 1 also shows, in yellow, the countries that benefited from joining the EU's Strategies in the first iteration, when joining the Strategies meant exclusive access to the EU's agricultural market. Once more countries decide to participate, however, the countries in yellow benefit more from leaving the strategies in subsequent iterations. This group of countries includes Canada, South Africa, Australia, and New Zealand, while notably excludes the UK.

Scenario 2: Global participation in the EU's Farm-to-Fork Strategies with the UK part of the EU

The recent departure of the UK from the European Union has presented an interesting question on whether it may be welfare maximizing for the former member to join the Strategies and how the reduced size of the EU might affect the participation in the Strategies throughout the world.

To answer these questions, we run a scenario of global participation in the EU Strategies with the former EU (including the UK).

Figure 2 shows the results of the simulation where the EU contains the UK as a member. The figure again shows in orange those countries that would join the Strategies and, in yellow, those countries that would join the Strategies if they received exclusive access to the EU's agricultural markets. With the EU containing the UK, more countries would find it in their interests to join the Strategies, most notably Australia and New Zealand. Because of the strong agricultural exports to the UK, these countries would join the Strategies if that meant preferential access to the UK market but not otherwise.

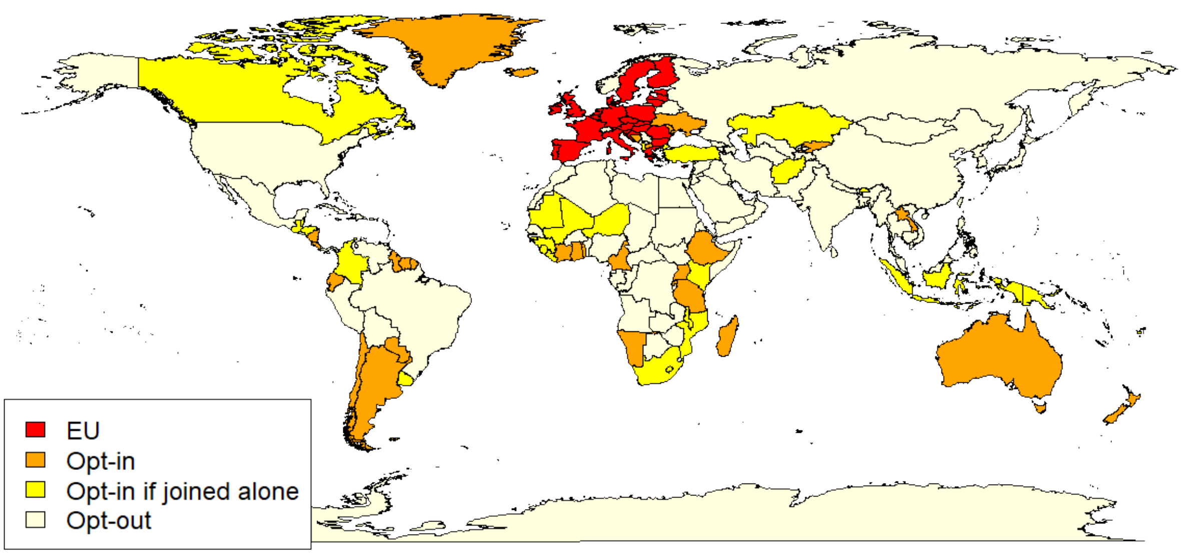

Figure 2: Participation in the EU's Farm-to-fork strategies if the UK were a member

The implication of EU's Farm-to-Fork expansion for the global economy

The results presented above identify a group of countries that would find it preferrable to join the EU's Farm-to-fork strategies, to avoid the speculated 50 percent NTM barrier imposed on their agricultural exports to the EU and other countries joining those strategies. In Table 1, we present the key descriptive statistics for the two groups. We calculate that the endogenous expansion of the Farm-to-Fork Strategies would increase the global population bound by those Strategies from the EU's 5.8 percent to 12.6 percent. The expansion of the Strategies to cover additional global agricultural output would be more limited: the EU's own share of global agricultural output of 14.1 percent would grow to 16.6 percent for all the countries implementing the Strategies. Under Scenario 2, where the UK is still part of the EU, the adoption of the Strategies would be wider, covering 14 percent of the global population and 20.1 percent of global agricultural and food output.

Table 1: Description of the Farm to fork adopting countries

	EU alone	Endogenous participation in the EU's strategies		
		EU	EU+UK	Middle scenario USDA study
Share of global population	5.8%	12.6%	14%	28.1%
Share of global agricultural and food output	14.1%	16.6%	20.1%	29%

The fourth column of Table 1 also compares our two endogenous scenarios with the middle scenario of the recently published USDA's report Beckman et al. (2020b) which assumed that regions that export a large share of their agricultural exports to the EU would join the Strategies. Based on this criterion, the report identified that 28 percent of the world population and 29 percent of world agricultural and food output would be covered by the Strategies. Because the level of participation assumed by the USDA report is much greater than that determined by countries' own determination, it is likely the value of access to the EU's agricultural and food market may in fact be smaller than assumed by the report.

The implementation of the global Farm-to-Fork Strategy with a 50 percent NTM barrier on agricultural and food imports into the countries that adopt the Strategies would result in large market impacts (Table 2). Under our scenario, global agricultural and food prices would rise by 7.3 percent, while global output would decline by 1.4 percent and global trade is estimated to decline by 7.1 percent. Under Scenario 2 with the UK and several additional countries participating, the increase in global prices would be even higher at 8.3 percent and the reductions in global output and trade greater at 1.5 percent and 7.3 percent, respectively. The market changes generated by our model are markedly smaller than those reported by the USDA report, especially for the change in the global agricultural and food price which is reported to rise by 21.5 percent in the USDA middle scenario. The reason for the smaller impact in our simulations comes from the fact that only those countries that would not incur excessive costs from joining the Strategies would decide to implement them, resulting in the most severe and disruptive market impacts avoided in our simulations, resulting also in smaller reductions in output and trade.

Table 2: Impact of endogenous participation in Strategies on global agricultural markets

	EU	EU+UK	Middle scenario USDA study
Prices	7.3%	8.3%	21.5%
Output	-1.4%	-1.5%	-4%
Trade	-7.1%	-7.3%	-9.3%

In addition to impacting agricultural and food markets, the expansion of the Strategies to more countries would have implications on global GDP and consumer food costs (Table 3). We calculate that global GDP would fall by $156 billion U.S. dollars. At the same time, food expenses for global consumers would grow by $42 (2020 US dollars) per person. Under Scenario

2 which includes the UK and several other participating countries, the GDP would fall even more by $182 billion and consumer food expenditure would rise by $46. Because self-selection for participating in the Strategies in our endogenous simulations is based on the welfare criterion, the welfare implications of our simulations are much smaller than that assumed by the USDA's middle scenario: instead of a reduction in global GDP of $381 billion, our simulations predict reduction of $156 and $180 billion, depending on whether the UK joins the Strategies as well. This self-selection for least welfare reducing choices also translates into much smaller impacts on global food costs: instead of an increase of $159 per person per year, our simulations predict an increase of $42 and $46, respectively.

Table 3: Impact of endogenous participation in Strategies on global welfare

	EU	EU+UK	Middle scenario USDA study
GDP	-$156B	-180B	-381B
Annual consumer food costs per person (2020 US dollars)	$42	$46	$159

Conclusion

The Farm-to-Fork and Biodiversity Strategies have led to considerable debate within the EU, pitting farmers who do not want to see their production costs increase against politicians who want to change the production structure. It has also led to considerable debate in the economics arena—revolving around market versus environmental impacts. While our work only considers the market impacts, we add to the literature on technology adoption/NTMs-by allowing the model to endogenously determine if a country should adopt the Strategies. Results indicate that some countries do adopt the Strategies—i.e., the benefits are larger for keeping trade with the EU (but increasing production costs) then losing the EU trade market.

The size of the group of countries that would choose to preserve their access to the EU market by adopting the Strategies in our model would depend on the size of the EU market. If the UK remained in the EU or joined the EU in adopting the Strategies, the benefit of maintaining the export market would exceed the welfare costs of adopting the Strategies for several additional countries (Australia and New Zealand).

Even though the results of our model suggest that through trade policy the EU could get their Strategies adopted by several additional countries, the overall adoption rate would remain low—our model calculates that the Strategies would not be adopted by more than 14 percent of the world's population or 20.1 percent of global agricultural and food output. Many of the key agriculture and food producing countries, including Brazil, China, Canada and the United States, would choose not to adopt the Strategies despite facing additional export restrictions.

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Appendix Table A-1. Sectoral aggregation

Name	Description	GTAP sector code
Paddy rice[1]	Paddy rice	Paddy rice (pdr)
Wheat[1]	Wheat	Wheat (wht)
Coarse grains[1]	Cereal grains	Cereal grains nec (gro)
Fruits and vegetables[1]	Fruits and vegetables*	Vegetables, fruit, nuts (v_f)
Nuts[1]	Nuts*	Vegetables, fruit, nuts (v_f)
Oilseeds[1]	Oilseeds	Oil seeds (osd)
Sugar[1]	Sugar	Sugar cane, sugar beet (c_b)
Other crops[1]	Other crops	Plant-based fibers (pfb), Crops nec (ocr)
Cattle[1]	Cattle	Bovine cattle, sheep and goats (ctl)
Hogs[1]	Hogs*	Animal products nec (oap)
Other animals[1]	Other live animals*	Animal products nec (oap), Wool, silk-worm cocoons (wol)
Milk[1]	Raw milk	Raw milk (rmk)
Natural resources	Natural resources	Forestry (frs), Fishing (fsh)
Energy/mines	Energy and mining activities	Coal (coa), Oil (oil), Gas (gas), Minerals nec (oxt), Petroleum, coal products (p_c), Mineral products nec (nmm), Ferrous metals (i_s), Electricity (ely), Gas manufacture, distribution (gdt)
Beef[1]	Beef	Bovine meat products (cmt)
Pork[1]	Pork*	Meat products nec (omt)
Other meat[1]	Poultry and other meat*	Meat products nec (omt)
Vegetable oil[1]	Vegetable oil and fats	Vegetable oils and fats (vol)
Milk products[1]	Milk products	Dairy products (mil)
Processed rice[1]	Processed rice	Processed rice (pcr)
Sugar[1]	Sugar	Sugar (sgr)

Processed foods[1]	Processed foods, beverages and tobacco	Food products nec (ofd), Beverages and tobacco products (b_t)
Labor manu	Labor intensive manufacturing	Textiles (tex), Wearing apparel (wap), Leather products (lea), Wood products (lum), Paper products, publishing (ppp)
Other chemicals	Other chemical products*	Chemical products (chm)
Fertilizers	Fertilizers*	Chemical products (chm)
Pesticides	Pesticides*	Chemical products (chm)
Capital manu	Capital intensive manufacturing	Basic pharmaceutical products (bph), Rubber and plastic products (rpp), Metals nec (nfm), Metal products (fmp), Computer, electronic and optic (ele), Electrical equipment (eeq), Machinery and equipment nec (ome), Motor vehicles and parts (mvh), Transport equipment nec (otn), Manufactures nec (omf)
Services	Services	Water (wtr), Construction (cns), Trade (trd), Accommodation, Food and servic (afs), Transport nec (otp), Water transport (wtp), Air transport (atp), Warehousing and support activi (whs), Communication (cmn), Financial services nec (ofi), Insurance (ins), Real estate activities (rsa), Business services nec (obs), Recreational and other service (ros), Public Administration and defe (osg), Education (edu), Human health and social work a (hht), Dwellings (dwe)

Note: [1] indicates a sector we consider as agriculture. * indicates a sector that has been disaggregated. Nec means not elsewhere classified.

Source: USDA, Economic Research Service using the GTAP-AEZ model

[1] Geography and domestic demand might also explain some differences, but those are not discussed in this work.
[2] However, WTO Agreements on Sanitary and Phytosanitary Measures (SPS Agreement) and on Technical Barriers to Trade (TBT Agreement) encouraged WTO members to harmonize national regulations with the international standards.
[3] In broader terms, self-selection refers to any choice made to be apart of something. In trade, self-selection choices could be to export (Haidar, 2012) to innovate (Bravo-Ortega, Benavente, and Álvaro González 2014), or to join a trade agreement (Baier and Bergstrand 2007).

[4] For these purposes, we use welfare as a measure of comparison. Future work could use any other sort of metric from a CGE model.

[5] This percentage is arbitrary but assumes that some producers in non-adopting regions might implement the Strategies (much like those who produce organic or natural products), or it accounts for products which are not produced with those inputs being reduced (e.g., processed foods).