Discrimination, Nutritional Quality and Resilience: Regulation in Agri-food Trade

By

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A thesis submitted to
the University of Birmingham
for the degree of
DOCTOR OF PHILOSOPHY

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March 2022

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ACKNOWLEDGMENTS

First and foremost, I am deeply grateful to my supervisors, Dr Sami Bensassi and Prof. Fiona Carmichael, for their patience, encouragement and enlightened advice throughout my PhD. This thesis would have not been possible without your tremendous support. Special thanks to Prof. Martyn Trybus, coordinator and mastermind of the EU Trade and Investment Policy ITN (EUTIP) project, for the opportunity he and Sami gave me to become a Marie-Curie fellow. I also thank to the European Commission for the generous funding provided and the superb Marie-Curie family the EU institutions have created. My gratitude to Prof. Gabriel Felbermayr, Prof. Peter Egger and Prof. Lionel Fontagné for their warm welcome and useful insights shared during my research visits at Ifo Institute, ETH Zurich and CEPII, respectively. To all members of the EUTIP project, who I have felt privileged to conduct research with. Special thanks to you, Alice. My office companion, my friend and my “family” in Birmingham from the very first day. Alla fine, ce l’abbiamo fatta.

I am grateful to Dr Cristian Morales-Opazo for taking me on board of his team at FAO and providing access to all resources I needed to conduct the last chapter of the thesis. I must also acknowledge the scholars who provided useful comments and support throughout these years. Prof. Anindya Banerjee, Prof. Robert Elliott, Prof. Emma Frew, Prof. Alessandra Guariglia, Dr Liza Jabbour, and Prof. Yoto Yotov. Thanks to all fellows from the Department of Economics, University of Birmingham, that helped to improve the thesis with their comments at the internal seminars and doctoral conferences. Special thanks to Emeritus Professor Peter Sinclair, whose passing shook profoundly in the department. His advice and support to young researchers was memorable.

I am also grateful to my PhD fellows at University of Birmingham. My colleagues on the 7th floor of Muirhead Tower, Hamideh, Bowen, Gianluca, Jade, Saul, Jorge. To my Italian family in Birmingham, whose friendship has been beyond important. Andrea, Marco, Federica, Simone, Giulio, I cannot wait to toast with you with a full glass of wine. Thanks to the Dynamo Keynes team, because our biweekly football matches have been vital to keep going through the PhD.

A final thanks to my beloved ones back home. To all my friends for the moral support and amusement provided when I needed it most. My friends Alex and Miguel for our endless geopolitical conversations. The Torreznos team for the trips and the fun I always have with them. To my friends in Zaragoza and around the world who cared about my research. Thanks to Raquel for her empathy and encouragement when the moral was low. I cannot wait to go campervanning and enjoy some good fresh air together. Y, por último, un agradecimiento a mi familia. Porque han sabido valorar en todo momento cuando necesitaba tiempo para mí y cuando necesitaba su apoyo sin pedir nada a cambio. Os lo dedico con todo el cariño del mundo.

This PhD has been funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 72916

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ABSTRACT

The multilateral trading system is one of the major achievements of international cooperation in modern times. The elimination of tariffs has led countries to specialize in commodities that allow them to exploit their comparative advantages while enabling access to other commodities in external markets. However, the system is not dynamic enough to solve long-standing issues or adapt to those arising as societies evolve. This thesis explores key areas in which action can be taken to achieve both direct economic benefits and indirect benefits through a more equal and more resilient global food system that can promote the nutritional quality of products. The core of the analysis is based on the gravity model of trade, but I also expound the mediation analysis as a method to be considered in the estimation of the indirect effects of trade measures. The results highlight the importance of trade facilitation as a tool to guarantee that developing countries –through capacity building and other practices– not only comply with regulations and enjoy equal market access, but also as a buffer in response to market crises. I also find that a loose quality control of food crossing the borders contributes to the ongoing obesity pandemic and suppresses the benefits of trade. Further commitments to market transparency, monitoring and evaluation would also contribute to a more resilient agri-food trading system.

Introduction

January 1, 1995, marked the start of a new era of commercial relations worldwide. The so-called Uruguay Round eventually gave rise to the creation of the World Trade Organization (WTO) after seven and a half years of negotiations between 123 countries. The WTO is conceived as rules-based, or a system based on rules. Out of the multiple binding agreements that were signed at its origin, the Agreement on Agriculture was designed to establish new rules specific to the agricultural sector. The agreement covered important areas such as market access, domestic support, export subsidies, sanitary and phytosanitary measures (SPS), and special provisions for least-developed countries dependent on food imports. It also built upon existing regulation that affects agri-food trade. For example, the Agreement on Technical Barriers to Trade (TBT) expanded the coverage and explanation of the technical measures covered under the agreement reached in the Tokyo Round.[1] However, many years have passed without a proper overhaul of the existing trade rules.

Technical measures are included in the list of items for the negotiating table in the Doha Round. The review of SPS and TBT Agreements is considered a priority by governments, as non-tariff barriers (NTMs) have been on the rise since the mid-90s (Ghodsi et al., 2017). However, the Doha Development Agenda is progressing at a slow pace, and it is currently lagging behind the issues arising both in international markets and the socioeconomic world.

[1] The Tokyo Round was the first attempt to thoroughly review the market conditions in the agricultural sector. The agreement included new commitments on tariffs, technical measures and export restrictions (Deardorff and Stern, 1983).

Globalisation has significantly contributed to the fast evolution of international economics in general and the agricultural system in particular. Value chains have stretched out and connected stakeholders around world. Trade liberalization has led developed countries to dedicate their capital and labour resources to other sectors or specific agri-food industries in which they can exploit their competitiveness, while relying on in imports to meet the demand of many other goods. Despite its rationale from a purely economic perspective, the multiconnected food trading system gives raise to multiple questions that are a matter of concern. Are countries equally benefitting from open trade? Are there underlying factors still hampering market access, particularly for developing countries? How is trade liberalization linked to the ever-evolving food consumption patterns? Is the agri-food system resilient enough to anthropogenic and natural disasters?

The objective of this dissertation is exploring these questions that, I believe, deserve further attention on the international trade agenda. The focus is on regulation in the form of unilateral trade policies or domestic policies affecting agri-food markets. NTMs are over-represented in the agricultural sector, justified by the need of high safety and health standards to protect consumers. The relevance of NTMs in international markets is out of discussion. Importantly, they cover not only measures at the border, but other policies with the ability to distort trade like food standards and subsidies (De Melo and Nicita, 2018b). Some NTMs, like quality certificates and packaging requirements, add to the costs of production while others directly affect trade costs (Nicita and Gourdon, 2013). They are thus a powerful mechanism for trade diversion and creation regardless of their purpose (Santeramo and Lamonaca, 2019; Disdier and Van Tongeren, 2010). With this in mind, NTMs play a central role in my analysis. However, I go beyond the standard ex-post evaluation of existing rules, as in Chapters 1 and 3, by also looking at aspects where the lack of regulation might be detrimental for the economy. This assessment is introduced in Chapter 2. Beyond NTMs, I also acknowledge the importance of other measures, many of them still used by governments to respond to emergencies or geopolitical tensions. My analysis of trade measures imposed during the pandemic do not only cover food standards, but also temporary provisions on tariffs, import quotas and more.

Chapter 1 addresses a controversial matter that has been spinning around for some time: the compliance of food standards with the principle of non-discrimination. This principle is at the core of the international trading system as one of the pillars in the General Agreement on Tariffs and Trade (GATT). The expansion of NTMs is noteworthy in the quantity, variety and number of countries imposing them (Nicita and Gourdon, 2013). What is even more remarkable is that they have proliferated at the same time that tariffs have been phased out. Existing evidence points out to the substitution effect of new NTMs when tariffs are reduced (Beverelli et al., 2014; Kee et al., 2009). Therefore, empirical evidence that commitments are fulfilled is necessary to reinforce the credibility and integrity of the multilateral trading system.

In this chapter, I test for the underlying discrimination of food standards. These measures are known to be non-discriminatory in nature, as they apply to all countries. Nonetheless, they can be discriminatory in practice, as both the time to adapt and the cost to comply with new rules vary across countries. My methodological approach relies on the gravity equation, which is considered the workhorse of trade economics. Heid et al. (2021) introduce a theoretical variation of the structural gravity model that allows for the identification of unilateral and non-discriminatory trade policies –as it is the case of SPS and TBT measures– while controlling for country-specific fixed effects. They argue that the introduction of domestic trade produces unbiased estimates. Intra-national trade is interacted with the NTM dummies, and therefore what I observe is a relative measure of discrimination. In other words, a negative parameter indicates that international traders are worse off compared to domestic producers post-treatment. To estimate intra-trade flows, I exploit the food balance sheets from the Food and Agriculture Organization of the United

Nations (FAO).

I evaluate food standards from two different datasets. The first group contains the bulk of measures recorded over the period 2000 to 2015. The second group contains Specific Trade Concerns (STCs). This is a subset of measures reported as concerning by WTO members. The estimates for the larger group are not statistically significant in the case of SPS measures, meaning that there is not generalized discrimination in the introduction of food safety standards. However, the results are negative and statistically significant in the case of TBT measures, implying that they provide market advantage to local producers. A more granular analysis reveals important findings. The parameter measuring the discriminatory feature of standards is negative and statistically significant in the period after the food crisis, particularly for SPS measures. Moreover, exporters from low-income countries have more difficulties than local suppliers to comply with standards. The gravity output for the STCs regression raises more warning signs. While this is a small group of measures, they have a strong distorting power and particularly hamper trade from a selection of countries. These are the countries raising the concern notification. This highlights the importance of trade facilitation programmes launched in developing countries as well as the need for better monitoring and evaluation plans that could prevent or swiftly identify the appearance of targeted and disproportionated food standards.

In Chapter 2, I test a hypothesis from the opposite approach. That is, what are the consequences of a non-regulated market. I thus depart from the potential economic implications of a deregulated market in the health system. The assumption is that open trade, in the absence of food quality control measures of foreign products, can encourage the consumption of cheap unhealthy food and drinks that contribute to the growing levels of the obese population. The link between trade liberalization and public health has been under scrutiny for some time now. Kickbusch et al. (2016) point to international trade as a key driver in the spread of non-communicable diseases. In a review of the laws shaping the multilateral trading system, McGrady (2011a) claims that the WTO law should be adapted to important health questions such as obesity. Imported food and investment flows in the food sector have the capacity to reshape people's dietary patterns (Barlow et al., 2017; Clark et al., 2012; Hawkes et al., 2012). Obesity rates have skyrocketed in Latin American countries the same as in the US, the largest producer of junk food. At the same time, some countries in the region have signed international trade treaties with the US over the last 30 years. This scenario provides a natural experiment that I exploit in the study. As trade agreements are often partly justified by their economic benefits, I test the indirect association of non-regulated markets with the raising costs of obesity in the region. A positive and significant coefficient would indicate that such economic benefits are undermined by a growing public health bill as no regulation is controlling for the nutritional quality of imports.

In a first step, I estimate the direct cost associated with obesity from public accounts. The methodological basis is the two-stage estimation of Fernández et al. (2017), although it is slightly modified to adjust for the data limitations. In the first step, I calculate the burden of disease, defined as the estimated disease prevalence associated with adiposity based on existing levels of obesity and overweight. Secondly, I estimate the cost of obesity using the burden of morbidity estimates and data on the direct healthcare costs for each disease. The output of this calculation acts as the dependent variable in the regression analysis.

For the causal estimation, I propose a novel methodology to capture the indirect effects of trade liberalization on the cost of obesity. The causal mediation analysis is an approach mostly used in psychology and other public health research, but it is gaining importance in international economics (Dippel et al., 2015; Khuong and Ha, 2014). This approach captures the indirect effects of a treatment –the deregulation of food markets, represented by a trade treaty with the US–, while controlling for all direct effects, including those of the variable of interest. The factors of interest are divided into 3 to observe the significance of each of them: imports of sugar-sweetened beverages, imports of junk food, and capital investment in the food sector.[2]

The mediation analysis uses data for the period 2000 to 2015. The results demonstrate the indirect association of junk food imports and, to a lesser extent, soda imports with the raising costs of obesity. Average causal mediation effect is large, significant, and positive in the case of junk food. The weaker results in the soda market might be explained by a higher market concentration. These large multinationals were established in some Latin American countries before 2000. The policy recommendations can go in several areas. For example, it can be introduced a “calorie tariff" similar to existing sugar taxes on products exceeding certain caloric levels. Labelling is an important source of information for consumers. Standardization and simplification might help consumers to better make more informed choices.

Chapter 3 also adds to the trade and public health debate. The COVID-19 pandemic has disrupted economies around the world. Yet, agri-food markets have behaved significantly better than other sectors (OECD, 2021; WTO, 2021). Governments have used trade policy as a response mechanism to the health crisis. Ahn and Steinbach (2021) find a strong association between COVID-19 cases and trade policy intervention in the agri-food market. However, there is little understanding about the role of trade policies in the visible resilience of the global agri-food system. Arita et al. (2022) assess the impact of the crisis using a set of COVID-19 indicators. This includes containment measures to stop the spread of the virus. The authors yet acknowledge that their gravity estimates do not capture the effects of trade measures. I address this unexplored area by capturing the effects of trade intervention during the pandemic. An important contribution of this study is in consolidating, cleaning, and completing information about measures that were scattered across multiple datasets collecting COVID-19 trade interventions.

[2]Investment data are only available for food manufacturing companies. I acknowledge that this is only a partial assessment of investment flows, as food retailers and wholesalers play a crucial role in the global food system.

As in Chapter 1, the theoretical framework is based on the gravity equation, but this time the model is not structural. The model relies on monthly data for estimation, and intra-trade data is not available in such frequent intervals. Additionally, the model is set up to accommodate the monthly dimension. The dependent variable, import flows, is thus displayed in the bilateral-product-month dimension. The model encompasses four treatment variables, grouped in import and export trade facilitating and restrictive measures.

One might think that markets would react in a similar precautionary manner to previous food price crises. Particularly, tight restrictions at the onset of the pandemic affected agricultural output and thus created the risk of panic buying, public and private food stockpiling, and thus trade distortions. What the study finds, however, is a different governments' trade policy response. Export restrictions were imposed now and then. Although there is still evidence about their negative effects on trade -–for example, they are associated with lower trade flows of cereals in the import-dependent countries–, they have not dominated international markets. This change in market intervention is a relief for international markets. The global price spikes during 2007–2008 demonstrated that export restrictions can have a double negative effect on prices, not just encouraging to buy more food and stockpile, but also reducing incentives for producers (Jensen and Anderson, 2017).

Actually, market intervention has been dominated by import measures. It was in fact import facilitation –that in numerous instances is a *de facto* reduction in import restriction of tariffs and quotas– the most recurrent type of trade measure up to June 2021. From tariff reductions and quota exceptions to the acceptance of electronic documentation, trade facilitation is observed across the board with a large, positive and significant influence on trade. These results highlight again the importance of trade facilitation to render market access and as an enabler of food security.

These chapters provide an empirical assessment on contemporary matters in the global food system and contribute to the discussion on the future pathways that trade policy strategies and the multilateral trading system should take into consideration. As the reader goes through the chapters, it will find that some above-mentioned questions are framed within ongoing public health concerns. The current epidemics have revealed the complex interaction between safety, food security and trade liberalization, and that they are far to go in a unique direction. Thus, this essay also helps to foster the debate in the agriculture-trade-health nexus.

Chapter One

Finding the Black Sheep: Discriminatory and Heterogeneous Effects of Standards on Agri-food Trade

Abstract

In 2015, Pascal Lamy, former WTO Director General, pointed to the changing international trading system. The old landscape of tariffs protecting domestic producers has been transformed gradually into a world of non-tariff measures to protect consumers. Standards have gained prominence in the agri-food industry, a sector traditionally characterized by high tariffs. A regulation can create spillover effects in the market, either positive or negative. The key question is understanding whether a rule complies with the principle of national treatment. This paper thus explores the existence of (non-)discriminatory effects between local and foreign producers. In particular, we test for differentiated effects of food standards (SPS and TBT) on foreign and local food producers. Our methodology evaluates the relative effect of these measures by incorporating domestic trade flows in a structural gravity model. Overall, the results do not indicate significant differences between exporters and local producers for phytosanitary standards, while do detect disadvantage in the compliance with TBT measures. However, our analysis identifies a growing number of measures with differentiated effects among producers after 2008, the year that marks the end of the food price crisis. We also find that low-income countries are more severely affected than any other group by measures introduced by developed countries. In contrast, regulation enacted by developing nations favours trade with the most developed. We also exploit the Specific Trade Concerns database to expand on the literature of regulatory heterogeneity. Our results suggest that the stringent effect of standards mostly comes from a few measures which, in turn, have an immediate and strong negative impact on a few countries. While most measures do not seem to distort imports, our last set of findings highlight the trade-restrictive power that some rules have in a targeted group of exporters. Efforts should be made to ensure the standardization and monitoring of disproportionate technical measures to guarantee a fair international trade system.

1.1 Introduction

One of the main rationales for trade openness is providing market access to everyone and letting competition and market forces interplay to determine trade flows. Trade liberalization should not deprive governments' from protecting their legitimate interests, such as citizens' welfare, animals' and plants' health, and the protection of the environment. Any WTO member is entitled to establish an optimal level of protection, but any domestic policy affecting trade must follow the principle of national treatment as set out in Article 3 of the General Agreement on Tariffs and Trade (GATT), regarding the introduction of national laws and regulation.[1] In the same manner, the national treatment principle is embodied in two WTO agreements covering numerous domestic laws affecting goods and services: the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical Barriers to Trade (TBT Agreement).

While there has always been multilateral consensus about the importance of the non-discriminatory principle for the good governance of the international trade system, it has not been exempted from controversy. Multiple trade disputes over the years have generated mistrust about how trade partners implement standards and rules. The last instalment (US-Tuna II) of the long series of disputes between Mexico and the United States over the Dolphin Protection Consumer Information Act and the labelling of tuna and tuna byproducts is such an example. The timing of the Hogarth ruling, rescinding the former decision of the US Secretary of Commerce to broaden the use of dolphin-free tuna labels to Mexican tuna in 2007, coincided closely - and some might have thought suspiciously - to the very

[1]"The products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution or use". (WTO, 1986)

moment were the last tariff barriers on Mexican tuna were eliminated in 2008.[2] In this same year, Mexico initiated a consultation, stating that the measures imposed by the United States were inconsistent with the obligations under the TBT Agreement.[3] The measure, deemed by Mexico as harmful for its fisheries industry, led to a lengthy legal process between two countries that had signed one of the most comprehensive trade agreements to date. If legal scholars have recognized that environmentalists and protectionism advocates could have convergent interests in this trade dispute, the WTO appellate body acknowledged the indisputable negative environmental impact of the fishing technique used by Mexican fishermen and ruled favouring the US (Elisa and Brunel, 2019).

Besides the protection of domestic producers, regulatory measures affecting trade have been linked to geopolitical motivations. The arrest by Canadian authorities in December 2018 of a Huawei's executive, Meng Wanzhou, preceded a Chinese ban on canola imports on the grounds of food safety concerns. The impact on Canadian farmers was immediate, as China is the biggest importer of Canadian canola.[4] Similarly, the War in Donbass caused a deterioration of relations between the European Union and Russia, with consequences for trade. In March 2014, the annexation of Crimea by the Russian Federation led to a set of travel bans and economic sanctions. One month later, Russia introduced a new import ban on pork and other pig products of EU origin based on concerns related to African swine fever. These controversial cases have often led to the conceptualization of regulatory measures as a protectionist and often discriminatory tool alternative to the imposition of tariffs. According to WTO figures, there are 49 cases referring to a violation of the SPS Agreement and 55 about the TBT Agreement for a total of 595 cases since the dispute settlement mechanism was introduced in 1995.

[2]According to World Banks' WITS database, US applied tariffs on Mexican tuna preparations were 11.7% before the signature of the North American Free Trade Agreement. Tariffs phased out and by 2008 all Mexican tuna imports enjoyed tariff-free access into the US market.

[3]A further reading on this trade dispute (DS381) is available on WTO's website: https://www.wto.org/english/tratop_e/dispu_e/dispu_status_e.htm.

[4]WTO Trade Dispute DS589

In other cases, even if domestic regulations have the genuine objective of protecting human, animal, and plant life or the environment, they may induce negative spillover effects on trade. For example, there is evidence indicating that interpretive front-of-pack labelling approaches, such as the 'traffic light labelling' commonly used in countries like the UK, are more effective for communicating nutritional information. However, this food policy has been subject to trade concerns as some countries express the difficulties their food producers face to comply with this regulation (Thow et al., 2018). These standards thus play a double-edge sword on trade. Even if consumers might perceive the compliance with the new regulation as a quality assurance and a reduction on information asymmetries, the high compliance costs may force the least efficient exporters to exit the market (De Melo and Nicita, 2018a).

These three examples exhibit the complexity of NTMs due to their underlying motivations, whether they are seen as a replacement for tariffs, a tool to protect political interests, or a guarantee to provide food to local consumers with high safety, quality and environmental standards. This disparity in the design and implementation of standards around the globe creates a problem for reaching consensus at the multilateral fora about the optimal level of regulation. The conceptual differences about NTMs, along with the rapid raise in the number of technical standards implemented in the last two decades, have anticipated the need for evidence on how these rules are reshaping the international trade system. In a famous speech at the ECIPE Conference in 2015, Pascal Lamy pointed to a new world where protection, in the sense of tariffs, plays a secondary role and precaution, in the form of regulatory measures, irrupts as a key determinant of trade.[5] The distinction is non-trivial as they are not assessed in the same way. It is widely accepted that tariffs restrict trade and in order to maximize international market interaction they should be eliminated. However, regulatory measures are necessary as they serve a primary function as a mechanism for managing risks associated with the production and consumption of goods. The problem resides in that each country

[5]Full speech available at https://ecipe.org/wp-content/uploads/2015/02/PLamy-Speech-09.03.15.pdf

has a different optimal level of precaution. The acceptable regulatory levels for consumers are different between countries and can take multiple shapes. Therefore, as the former WTO Director General pointed out, regulation is heterogeneous by nature and there is a need to understand how this heterogeneity affects the economic agents and how the differences can be reduced. This study focuses on agri-food products, as they have been traditionally subject to high levels of tariffs, and now they are heavily regulated by a broad spectrum of SPS and TBT measures. In fact, over 80 per cent of agri-food products worldwide are affected by at least one SPS measure, while TBT measures affect more than 60 per cent of the products (De Melo and Nicita, 2018a).

The contribution of this paper to the evaluation of non-tariff measures (NTMs) is threefold. First, we examine the (non-)discriminatory nature of domestic regulation on SPS and TBT measures by analysing whether there is a different impact on foreign suppliers compared to local producers. We deepen our analysis by examining any differential effect of standards on producers over time and comparing measures with and without concerns reported to the WTO. Second, we contribute to the literature on market access limitations for low-income countries, as we compare the effects of agri-food regulation across different income groups. Finally, we add to the literature on the heterogeneous effects of food standards by investigating whether countries raising or supporting a concern at the WTO are affected differently compared to other trade partners.

We conduct an empirical analysis based on structural gravity, as it is the cornerstone for trade policy analysis.[6] Nevertheless, while structural gravity has been extensively applied in the evaluation of NTMs, researchers face econometric problems producing consistent estimates. As established by the SPS and TBT Agreements, technical standards are unilateral non-discriminatory measures. The dimension of this type of regulation is therefore importer-

[6]Regulatory standards cannot be considered purely as trade policies, but as they are measures having a direct impact on importers and exporters they can be studied in trade models.

product-time specific.[7] The evaluation of technical measures using the gravity equation has suffered from methodological challenges. Studies that do not control for the multilateral resistance term (MRT) tend to overestimate the "barrier" effect of these policies (Li and Beghin, 2012). Additionally, Head and Mayer (2014) proved that unilateral trade policies and other country-specific factors cannot be identified in gravity contexts that use importer and exporter fixed effects. To overcome this problem, we rely on the approach of Heid et al. (2021), who show that it is possible to obtain consistent estimates in the presence of importer and exporter fixed effects. The authors interact the unilateral trade policy with a dummy variable that identifies whether a traded product crosses an international border. To the best of our knowledge, this is the first study to investigate the discriminatory nature of food standards by comparing international trade to changes in domestic sales while overcoming these methodological problems.

Our primary results compounding all countries and years suggests that, overall, there is a weak correlation between the implementation of SPS measures and relative gains for domestic or international producers. The coefficients for TBT measures do project certain disadvantage for international as they lose market in favour of domestic producers. We dig deeper into the implementation of rules over time and across countries and note a marked trend towards discriminatory measures after the food price crisis. The post-crisis period coincides with a surge in the number of measures introduced. It is not clear whether the increase arises from countries safeguarding their local markets from high international price dependence or it is a response to increased demand for consumer, animal and plant protection. From our findings, we can conclude that a close monitoring of NTMs and further multilateral dialogue is required to minimize the impact of regulation on international trade. Second, we find that measures imposed by high-income countries tend to harm market access for the poorest exporters, while exporters from high-income countries tend to benefit when low-

[7] Certain measures are even importer-time specific, as they affect all products in the sector, but they are dropped from the database.

income countries introduce new standards. This is particularly noticeable for SPS measures, which represent the bulk of the rules applied to agri-food products. These results highlight the appropriateness of trade facilitation programs for developing and least-developed countries.

We also incorporate the STCs database to search for heterogeneity in levels of discrimination within the same group of measures. Both SPS and TBT measures with concerns negatively affect foreign producers, but the latter show higher heterogeneity. The relative impact of TBT measures varies from significant losses for measures with concerns to positive effects for other measures. STCs represent a small subset of measures within the ocean of NTMs. Therefore, our results align with the standpoint that a high number of NTMs over a specific product does not necessarily mean more regulatory stringency (De Melo and Nicita, 2018a). One implication is that, generally, prevalence score is not a good indicator in the analysis of the trade-restrictive effects of NTMs.[8] A second implication is that exporters tend to identify stringent measures quite accurately, and countries imposing the measures should carefully consider taking action once a concern is raised at the WTO specific committees. Finally, we examine the existence of heterogeneous effects across different trade partners. We can conclude that trade-restrictive effects of STCs are strong, immediate and highly concentrated in the group of countries raising the concern. These findings pose questions about the ultimate goal of certain standards. We might expect that the spillover effects from a regulation introduced in good faith are common to all producers. Instead, the effects are like those typically observed for protectionist measures.

The remainder of the paper is structured as follows. In Section 2, we introduce the concept of NTMs and explain why they have gained prominence in the trade literature. Section 3 presents a selection of studies in the analysis of NTM effects on trade, with particular emphasis on those relevant to agricultural trade. Section 4 describes the data and explains the calculations made in the construction of variables. The gravity model is presented in Section

[8] The prevalence score accounts for the number of measures applied to a given product line.

5. Section 6 comments on the results and presents the work on the analysis of heterogeneity across partners using STCs. Section 7 introduces a series of sensitivity tests that provide consistency with our findings, and Section 8 concludes.

1.2 Background

In this section, we briefly introduce some background knowledge on technical measures and on the principles that shape domestic regulation within international trade commitments. Non-tariff measures are defined as policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices, or both.[9] The NTMs classification encompasses 16 chapters corresponding to alphabet letters from A to P. Each individual chapter is divided into groupings and sub-groupings. For example, labelling requirements for food safety and quality receive the code A31, within the heading A3 "Labelling, marking, and packaging requirements" and Chapter A, Sanitary and Phytosanitary measures. This chapter encompasses all measures adopted by governments to ensure that food is safe for human consumption and prevent the spread of pests or diseases among animals and plants. Chapter B refers to Technical Barriers to Trade, which are measures adopted by governments establishing product requirements for fulfilment of public policy objectives, such as human health and safety, environmental protection, consumer information, or quality. All these measures must be applied to both domestically produced and imported goods in a non-discriminatory manner as stated by the principle of national treatment, Article 3 of the General Agreement on Tariffs and Trade (GATT), about the introduction of national laws and regulation. The principle of non-discrimination is also stated in the SPS and TBT Agreements, and higher levels of protection beyond international standards should be grounded in scientific evidence. In other words, the SPS and TBT

[9] Unlike non-tariff barriers, or NTBs, which are considered trade-restrictive, NTMs can lead to either positive or negative trade shocks.

Agreements encourage domestic policymakers to bear the cross-border effects in mind when drafting new regulatory instruments and minimize the regulatory diversity.

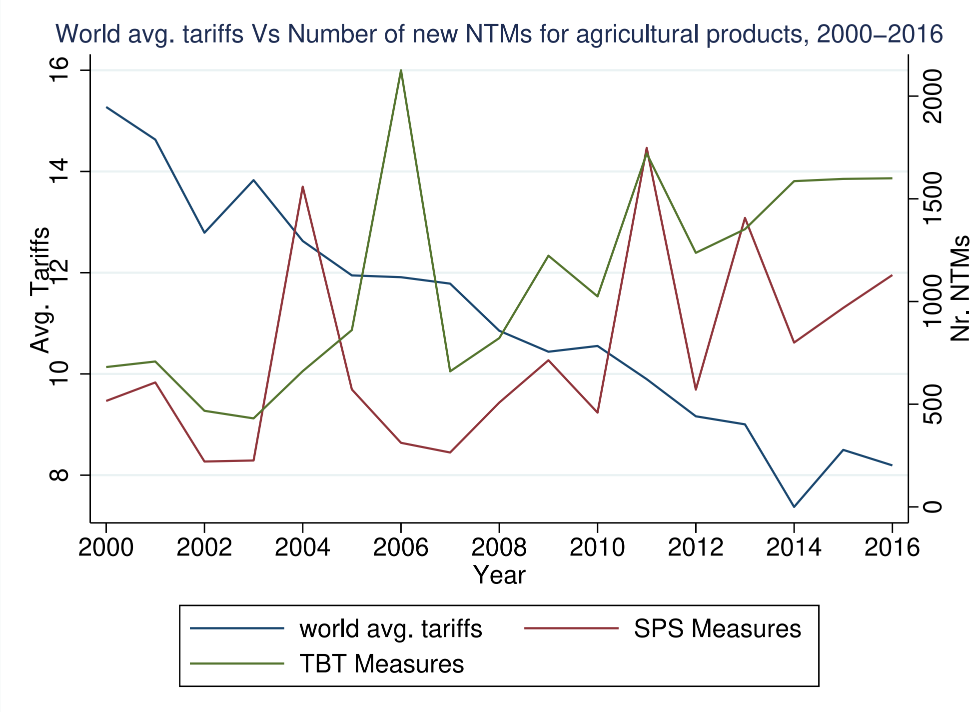


Figure 1.1: Tariff data obtained from World Banks's WITS database. Aggregation is authors' own calculations. NTM numbers refer only to multilateral measures.

As part of the Uruguay Round signed in April 1994, the Agreement on Agriculture established a set of commitments to improve international market access. Countries agreed on a gradual reduction of agricultural custom duties, as well as a "tariffication" process that implied the elimination of previous non-tariff barriers.[10] After the abolition of these barriers, mainly quotas and import bans, the number of new NTMs has been on the rise. The escalation on technical measures has been particularly pronounced in the agri-food sector, which has been traditionally characterized by high levels of tariffs. Figure 1.1 illustrates a visual representation of these opposing trends in agricultural products. These data have not gone unnoticed by governments and have led to debates over the ultimate purpose of certain

[10]The Agreement on Agriculture entered into force on the 1st of January 1995 and tariffs were reduced by an average 36 per cent in the case of developed countries over a six-year period and 24 per cent in the case of developing countries over a ten-year period. Least-developed countries were not required to reduce their agricultural tariffs.

rules. Some studies have shown empirically the existence of a policy substitution effect in manufacturing and agricultural products, at least in those standards subject to concerns by exporting countries (Beverelli et al., 2014; Orefice, 2017). Many of these concerns relate to lack of transparency in the implementation process, either as a result of late notification of measures or insufficient clarity in the regulation. Similar findings have been found on measures specific to the agri-food sector, (Crivelli and Gröschl, 2016). Given the evidence, one may wonder whether NTMs are used to replace, at least partly, former levels of tariff protection acting, as substitutes. Policy substitution, characterized by the tightening of standards following a tariff reduction, is likely to occur when domestic producers find it relatively less costly to meet the standards than foreign producers. Therefore, finding heterogeneous effects in local and international food producers might also be an indicator of a hidden policy substitution strategy.

1.3 Literature Review

The relevance of non-tariff measures in trade research is reflected in the exponential growth of published articles in the last two decades. Initial studies mostly focused on the quantification of NTMs, where two econometric approaches stand out: the quantity-based method and the price-based method. While the objective in both approaches is estimating *ad valorem* tariff equivalents, they are based on different methodology and data. The quantity-based approach is the most widely chosen by economists and exploits bilateral trade flow variation in the presence of NTMs using gravity equations (see for example Kee et al., 2009). The price-gap approach, considered a more direct approach, compares the price of similar products with and without NTMs. A seminal study on this method is Cadot and Gourdon (2016). These studies are particularly attractive, as they provide a quantitative measure of NTMs that can be subsequently used in market simulations and the estimation of relevant indicators, such as production, imports and exports, prices and welfare.

Another growing strand of trade literature on NTMs focuses on understanding better their effects. Countries diverge in the form and intensity of consumer, animal and plant protection. Consumers' perception over foreign products and food quality and safety varies in each country. Equally, producers' capacity to adapt to new standards also differs. This diversity in NTMs and countries' response to NTMs might explain why the empirical evidence on the effects of non-tariff measures is characterized by a wide heterogeneity. Differences also prevail across sectors. In their meta-analysis, Li and Beghin (2012) observe that the agri-food sector tends to be more negatively affected by technical measures on average.

Diversity also emerges from the regulatory requirements of a measure. Webb et al. (2019) disentangle the effects of SPS and TBT measures that involve compliance measures, whether testing, inspection or certification. The authors find that these measures reduce the number of countries exporting to the market where the standards are introduced, while the measures that do not have a compliance component enhance trade. These results follow previous estimates from Crivelli and Gröschl (2016), who also investigate the effects of NTMs by type of measure. The authors use data on Specific Trade Concerns, and distinguish between measures of conformity assessment and those related to product characteristics. The latter group consists of measures related to requirements on quarantine treatment, pesticide residue levels, labelling or packaging. As Webb et al. (2019), they find that conformity assessment related measures act as a barrier to market entry. However, they add that concerns related to product characteristics positively affect trade value. Such findings suggest that these measures can boost the intensive margin of trade by reducing asymmetric information between consumers and producers. Although standards imply compliance costs, they also imply higher utility for consumers based on the perceived upgrade on quality and safety, and thus increasing the demand. A similar study using firm-level data is Fontagné et al. (2015). The authors also discuss the effects of SPS measures on the extensive and intensive margin of trade using data on STCs. They find that trade-restrictive SPS measures reduce the probability of French firms to export by 4%, while the negative impact on the value of exports is around 18%, with lower effects for large exporters. These findings suggest that technical standards can lead to a diversion of trade. Overall, studies using information on STCs have found trade-distorting effects in measures responding to tariff reductions. Orefice (2017) found that reductions in import duties triggered the rise of more trade-restrictive SPS and TBT measures. These measures then translated into concerns at the WTO committees. Beverelli et al. (2014) observed policy substitution of NTMs for tariffs in both samples of TBT and SPS concerns even if using only"new" measures, that is, measures introduced years after the tariff cut. Ning and Grant (2019) conduct a thorough evaluation of the trade-restrictive effects of SPS measures raised as concerning on trade flows across the top 30 agricultural trading countries. The authors incorporate STC treatment variables in their gravity equation, and they find significant trade-reducing effects.[11] These findings raise the question whether all SPS and TBT measures, and not just the sub-sample of measures with concerns, are designed with a similar underlying purpose.

Divergence in exporters' response to new regulation has also been the focus of interest in recent research. Nicita and Seiermann (2016) pool NTMs imposed in thousands of products by G20 countries into a cross-sectional gravity model. They find that the measures substantially impinge trade from the Least Developed Countries. In a study with a similar product and NTM scope, Essaji (2008) come to similar conclusions in their analysis of US regulation. The methodological approach is different, as the authors carry out an instrumental variables estimation using regulation from New Zealand, Australian and Japan as instruments. Research tailored to the agri-food sector has also found that poorer countries are the worst impacted by food standards. Disdier et al. (2008) found that measures imposed by OECD countries have a strong and negative effect on exports from low-income countries, likely due

[11]In fact, the authors use two dummy variables, one during the period the STC is active and another post-resolution. The authors also evaluate the effects by type of measure.

to the lack of technical and institutional capacities to deal with health, safety and technical standards. Indeed, by increasing the cost of exporting, technical standards may reduce the number of competitors in the market, in turn reducing the number of varieties available to the consumers and unevenly affecting different-sized exporters. Murina and Nicita (2017) find the same effects on SPS measures imposed by the European Union. However, these studies are based on cross-sectional gravity estimates, and provide limited external validity. Studies based on panel approaches have focused on very specific types of SPS measures, such pesticides, Maximum Residue Limits and aflatoxin standards (Ferro et al., 2015; Otsuki et al., 2001; Xiong and Beghin, 2017). Our study fits into this gap by exploring the diversity of effects on agri-food exporters in a panel gravity data approach using a large sample of standards.

Most studies cited above use gravity to identify the properties of SPS and TBT measures. However, Li and Beghin (2012) argue that such studies fail to properly control for the multilateral resistance term and tend to overestimate the stringency of NTMs. A common approach to control for MRTs in panel data contexts where time-varying covariates are not typically available is using importer and exporter fixed effects. Head and Mayer (2014), identify other challenges with this approach, as unilateral policies that equally apply to local and foreign products cannot be identified. Heid et al. (2021) suggest incorporating domestic demand when analysing unilateral trade policy measures. This method avoids potential collinearity issues derived from the use of the classic set of country-time fixed effects. The authors validated their method for the analysis of unilateral trade policies that affect differently domestic and international demand. In particular, they explore the impact of MFN tariffs and time-to-export as determinants of change in imports and exports, respectively. A later study, Beverelli et al. (2018) show that this method allows for the identification of country-specific variables, such as food standards, that affect local and foreign products in the same manner. The difference resides simply in the interpretation of the results. In the latter case, the estimates measure the *relative* impact in international trade regarding the national demand. Thus, we use this approach to explore unilaterally implemented SPS and TBT measures, that affect equally to local and foreign producers.[12]

Theoretically, there is little evidence about the discriminatory nature of NTMs. Many studies show that technical measures impose market restrictions, but trade might be diverted to other countries, exporters or products. In other words, governments should not provide a competitive advantage to national producers or improve their competitiveness in some way as a consequence of the new regulation. If national producers do not face such impediments or the regulation is designed in a way that they can cope more easily with any associated cost, we should observe an increase in local trade as a result of this relative competitiveness gain. To our knowledge, only GTAP proposes a methodology to identify discriminatory measures. However, its novel NTM database excludes SPS and TBT measures, as countries have an "uncontested higher motives" to impose them (Evenett and Fritz, 2020). These motives are multilaterally accepted goals that go beyond frictionless trade and are formalized in international resolutions, such as the SPS and TBT Agreements. Therefore, one of our major contribution is the assessment of the discriminatory nature of food standards using constructed intra-national trade data. This approach, proposed by Heid et al. (2021), also copes well with the problem related to estimation bias.

1.4 Data description

Gravity equations require a comprehensive set of variables, both bilateral and country-specific, to determine bilateral trade flows. Constrained by information on detailed regional trade agreements, our estimation extends over the period 2000 to 2015. Our sample covers

[12]UNCTAD TRAINS also collects bilateral measures, but we filter by measures that are implemented across the world.

161 WTO countries (out of 164 members) and 157 agricultural products at the four-digit level of the Harmonized Commodity Description and Coding System (HS).[13] The main reason to use this level of product aggregation is because it mitigates the problems derived from the product code conversion from FAO codes into the HS classification. Given that our interest is in testing for the potential differentiated impact of domestic regulation on international trade relative to domestic demand, we drop data when there is no domestic production for a specific country-product pair. For example, we have data on imports and stocks of palm oil in the EU, but not a single member state produces palm oil. Therefore, any SPS or TBT regulation on palm oil imposed by the EU is not included in the study.

1.4.1 Bilateral Trade Flows

We extract bilateral trade flows in agri-food from FAOSTAT, a database maintained and managed by the Food and Agriculture Organization of the United Nations (FAO). FAOSTAT is a comprehensive and publicly available database covering most agricultural products, both raw and semi-processed. The Detailed Trade Matrix is composed of various data sources, mainly UNSD's International Trade Statistics Database (COMTRADE), Eurostat and other national authorities. It provides both national import and export flows in value (in thousands of US dollars) for each year, including data on food aid.[14] The results reported in our regression are based on import statistics, as these are generally preferred over exports (Bacchetta et al., 2012). The database is coherent with production and producer price data, as they are based on the same classifications. FAOSTAT data therefore meet our requirements to construct a consistent trade database, incorporating intra-trade flows.

[13] Most products in our sample fall within Chapters 1 to 24 that refer to agricultural and food products. Some byproducts from agriculture outside those chapters are also included, such as leather, cotton, silk, wool and certain types of oils and fats.

[14] Agricultural exports are reported in FOB (Free on Board) values and imports in CIF (Cost, Insurance and Freight) values.

FAOSTAT data arrange products using FAO Commodity List (FCL) codes, which is an internal classification system. FAO provides conversion tables for FCL codes to the 2007 version of the Harmonized System at the six-digit level.[15] However, FCL codes are very aggregated. They usually refer to various six-digit codes and, in some cases, do not correspond to a single HS four-digit code. In this context, we have considered two alternatives to assign FCL to HS four-digit codes: (i) use a simple average to assign trade data to different four-digit codes under the specific FCL code, as it is not possible to identify the shares belonging to each four-digit code or (ii) keep only the data for which there is a perfect pairing, that is, an FCL code matching products falling within a unique four-digit heading. Results reported in our main regression use the simple average. However, we report the results using the second alternative in Appendix A.5 for robustness.

Intra-national trade

Domestic demand data, represented in our equation as intra-trade when j equals i (X_{ii}), are not readily available. Intra-trade flows are calculated as annual production minus exports (X_{ij}) and minus stock variation with respect to the previous year.

$$X_{ii,t} = Prod_{i,t} - X_{ij,t} - \Delta Stocks_{i,t} \ \forall j \neq i \tag{1.1}$$

In our sectoral analysis, we use gross production data in values from FAOSTAT, where the value of production refers to production in physical terms multiplied by price at the farm gate. FAO coins the term "value of gross production" because it accounts for the whole quantity of production independently of the final use of the product (food, feed

[15] For more information and conversion tables see http://www.fao.org/economic/ess/ess-standards/commodity/en/.

and seed demand) and applies a unique price, even if in the real world this price might change depending on the use. Data are readily converted to constant values using average international dollar prices for the base period 2004-2006. Production quantities are measured at national level in tonnes or in heads of live animals. The main source of the data comes from FAO member countries official statistics. This is, either through annual production questionnaires (APQ) distributed to countries, from national publications or from official country websites.[16]

Previous trade literature with intra-trade data constructs their information uniquely using production and exports as in Wei (1996). Yet, we consider that incorporating stock data will mitigate the probability of measurement errors in our calculation of agricultural intra-trade flows. Governments base their food security policies on their staple crops. Therefore, there can be correlation between high stock levels and governments' trade policy intervention, particularly marked during food price crises such as the one between 2006 and 2008 (Demeke et al., 2008). FAOSTAT provides information on annual stock variation in its food balance sheets, but it is only reported in volume.[17] To estimate its value, we use annual producer prices, which are also available in US dollars per tonne on FAOSTAT. However, there is no information on stocks for all countries. This is due to both a lack of reporting and trivial stocked quantities, particularly in countries with small populations.

[16] In instances where no official data is available, data from semi-official sources may be used. If no data from either official or unofficial sources is available, data are imputed. In all cases, data are flagged accordingly.

[17] After calculating intra-trade data using Equation 1.1, around 16% of the observations lead to negative values. This can be explained in part by the use of different product classifications. For instance, FAO uses a different classification of products for prices and market data. Therefore, price data applied to stocks volume is not perfectly accurate. Data with negative values is transformed into zeroes for the econometric analysis.

1.4.2 Tariffs

Tariff data are obtained from World Bank's World Integrated Trade Solution (WITS) website.[18] The WITS database classifies tariff data into four different groups. In our regression, we use effectively applied tariffs, which represents the lowest tariff available for each country-pair, product and year. That is, it takes bilateral preferential tariffs at the HS six-digit level, when available. It takes effectively applied Most Favoured Nation (MFN) tariffs otherwise. Eventually, it takes bound tariffs –which represents the maximum MFN tariff that can be applied– as a last resort. Countries report tariffs using different HS versions. The data are appropriately harmonized with the HS 2007 classification for consistency with FAO data.

There are different approaches to aggregate tariffs in the literature. The most common ones take simple averages or calculate import-weighted averages. However, the former does not account for the relevance of each product in trade flows within each four-digit heading. The latter tends to underestimate tariff restrictiveness when they are very high (Guimbard et al., 2012). We follow a similar approach to Disdier et al. (2016), aggregating tariffs at the four-digit level by using country reference groups to minimize the trade-tariffs endogeneity problem.[19] The weights based on the reference country groups allow for a better accountability of restrictive transaction costs. The reference period used to calculate the weights is the period 2006-2008, as in Guimbard et al. (2012). The weights are calculated as follows:

$$W_{p,i,j} = \frac{M_{p,i,R(j)} * M_{.,.,j}}{M_{.,.,R(j)} * M_{.,i,R(j)}}, \tag{1.2}$$

where $W_{p,i,j}$ is the weight used in the aggregation using product p exports from country i to country j. M refers to imports and $R(j)$ is the reference group of the importing country.

[18] The annual tariff dataset originates from the UNCTAD Trade Analysis Information System (TRAINS).

[19] For a detailed explanation on the Reference Group Methodology, see Bouët et al. (2008) and Guimbard et al. (2012).

The symbol "." refers to the total value. Therefore, $M_{.,.,j}$ are the total agri-food imports by country j.

$$tariff_{ijP} = \frac{\sum_{p=1}^{a1} t_{ijp} * W_{ijp}}{\sum_{p=1}^{a1} W_{ijp}} \quad \forall p = 1, ...a1, ...n, \tag{1.3}$$

Once we have computed the weights, we proceed with the calculation of weighted tariffs at the four-digit level using WITS tariff data (t_{ijp}). We take the summation, where $a1$ refers to the set of products of the six-digit subheading within its corresponding four-digit group.

1.4.3 Non-Tariff Measures

Information on SPS and TBT measures is collected yearly by UNCTAD and presented on the UNCTAD's TRAINS database. The database contains information such as the reporter, the type of NTM, the HS-6 product code, and the date of enforcement. All kinds of rules are collected and included in the database, regardless of their effect on trade. UNCTAD provides a readily available data file for researchers. However, this file does not include information on an important variable for our analysis: *alsodomestic*. This variable, which can be found on the UNCTAD's bulk data, identifies whether a measure applies to all products or alternatively to only imported products. By definition, our assessment of non-discriminatory regulation requires of measures applying to both local and foreign agri-food products. Therefore, we resort to the more comprehensive UNCTAD's NTM register. The information on *alsodomestic*, however, is not available for all measures. For a relatively important group of notifications (23% for SPS and 16% for TBT), UNCTAD cannot identify the market scope of the measure, and they are reported as undefined. Cutting out undefined measures would significantly shrink our sample. Besides, technical reports suggest that the vast majority of NTMs also apply domestically (UNCTAD & World Bank, 2018). Thus, our main regression contains measures for which domestic application is not specified, assuming that they are equally applied to local producers. Because of the lack of information regarding the date when the measures come to an end, we also assume that once notified, measures are in force in the following years otherwise specified. These are two limitations to take in consideration that might affect our results. Cleaning our database also comes at a cost. The lack of product codes for notifications in certain countries leaves out an important group of countries, mainly from the Latin American region. In the robustness section, we discuss the results using the UNCTAD file that does not identify the market implementation of the measure, but provides a larger country coverage. A comparison of both datasets is presented in Appendix A.1.

In our analysis of possible heterogeneity inherent to SPS and TBT measures, we also require from WTO's STCs database. STCs are interpreted as an informal way to resolve trade tensions in which a member or members notify to the SPS and TBT Committees, or through an official notification. They are considered a softer way to solve trade issues aside from the legally formal and often longer Dispute Settlement mechanism.[20] The advantage of the STC dataset is that we can follow a single concern overtime, from rising to resolution, and allows for a good tracking over time. It provides information on the country or countries raising the concern and the country imposing the measure, the product codes at the HS four-digit level, the year in which the concern was raised, whether it has been resolved and when, and information on the primary subject of concern. As for SPS measures, there is also information on the country or countries supporting the concern. Note that a dispute that has been resolved might still be recorded on WTO's database as "Not Reported" or "Partially Resolved". This is because the member, or some of the members, that raised the concern have not notified the resolution of the conflict (Horn et al., 2013).

[20] If the members involved in a concern cannot solve it through consultations or bilateral talks, the conflict can be raised to the dispute settlement system. Up to 2018, only 3 per cent of the STCs became a legally formal dispute (Karttunen, 2020)

It is worth noting that these databases identify the product on which a concern is raised and not the product on which the measure is imposed. Therefore, it excludes products that are included in the measures, but that are not the object of concern as evinced from the minutes. If at least one product within the four-digit heading is subject to an STC, the dataset registers the measure as concerning for the whole set of products within that heading. Occasionally, the product information is reported as a description, in which case we matched it with the most suitable 2-digit or four-digit group based on descriptions from the HS 2007 Nomenclature. Finally, product information was missing in some cases.To complete the missing information, we used national sources to complete the information, when available, and otherwise dropped. For example, we verified information with USDA's GAIN database, in the case of US concerns, and EU's Market Access Database.[21] Similarly, we called on national sources if there was no information on the resolved date of a concern. Alternatively, we assigned to the raised date the average duration calculated from the available observations. Unlike the SPS dataset, there is no information on when TBT concerns were resolved, but only on the last time they were raised. We take this information as a proxy for the resolution date as often no further notifications meant the concern was settled but just not reported –specially when the STC was raised only in one or two WTO meetings– Horn et al. (2013). We have, thus, gone beyond WTO's work on collecting information on STC. For this reason, we deem this database is, to our knowledge, the most completed dataset available for STCs related to the agri-food sector.

1.4.4 Preferential Trade Agreements and Bilateral Trade Costs

For our set of explanatory variables, we use information on bilateral trade relations. As our focus is on TBT and SPS measures, we decompose the information on regional trade

[21]In a few cases, when the measure is imposed by multiple countries the STC report refers to them as "certain countries". We also completed this information when possible with the help of national registers.

agreements to identify those with specific provisions on SPS and TBT measures. For this purpose, we use World Bank's data on Deep Trade Agreements, which allow us to set dummy variables defining the key features affecting the agri-food sector in bilateral agreements. Unlike the classic variable used in gravity studies identifying the presence of a regional trade agreement, we use four dummy variables to capture trade commitments on SPS, TBT, and other non-tariff measures agreements, as well as other arrangements beyond the scope of the current WTO mandate in the agricultural sector.

Some country-pair doublets are recorded multiple times in certain years if they have multiple agreements in place all at once. For simplicity, we drop agreements that extend country-pair trade relations but still do not imply a change in either SPS or TBT commitments (or both). We also filter out those agreements that do not include provisions on SPS and TBT. Still, there are country-pairs that appear more than once in the dataset after applying the filtering criteria. In those cases, we select the deepest agreement. The World Bank's database identifies whether a provision mentioned in the agreement is legally enforceable, assigning a value of 2, and equal to 1 otherwise. Using this information, we can construct a *depth score* and select the agreement that implies further bilateral trade commitments, by selecting the one with the highest score.[22]

In the same manner we incorporate information that tends to facilitate trade, we need to incorporate measures that might hinder it. Unfortunately, trade costs between countries are unobservable, and they need to be proxied with observable variables. A common practice in gravity estimation is to include time-invariant covariates such as physical distance, border contiguity, common language and colonial links (Yotov et al., 2016). This information is

[22]For example, the Russian Federation has signed multiple agreements with several post-Soviet republics, such as the Commonwealth of Independent States, Eurasian Economic Community and at bilateral level. However, only the former introduces legally enforceable commitments on SPS ant TBT measures, and it is therefore our selected agreement. Even if subsequent trade deals might integrate the signatories further, they do not necessarily have an impact on our dummy variables. This is the case of the Common Economic Zone, signed in 2004 between Russia, Belarus and Kazakhstan. The agreement, however, does not suggest changes in our indicators of SPS, TBT and other agricultural measures.

available on CEPII's GeoDist database.[23]

1.5 Model Specification

The gravity model has become the workhorse in international trade policy analysis. Anderson and Van Wincoop (2003) adapted elder versions of the gravity equation in a model consistent with foundations of economic theory. One of their major contributions was identifying the existence of an external force that affects bilateral trade beyond importer-exporter pure relationship. That is, bilateral trade depends on the inward and outward ease of markets access for importers and exporters, respectively. Anderson and Van Wincoop defined these factors as the multilateral resistance terms (MRTs). One of the main challenges in the gravity approach is that these multilateral resistances are not directly observable. As Li and Beghin (2012) exhibit, failing to control properly for the multilateral resistance term can lead to overestimating the trade impeding effects of technical measures, such as food standards. A common and simple method widely used in the trade literature consists in using directional country-specific –importer and exporter– fixed effects.[24] Events that can potentially stir up markets from one year to another, such as macroeconomic shocks and exceptional weather conditions affecting nationwide agricultural production –e.g., El Niño phenomenon– are thus well accounted for.

Head and Mayer (2014) dig deeper into the methodological challenges originating from the multilateral resistance terms. The authors state that, when we control for the multilateral resistance terms using importer and exporter fixed effects, unilateral policies affecting all trade partners –such as SPS and TBT measures– cannot be identified. The traditional gravity

[23]Distance between countries is calculated using the "great-circle" formula, taking as reference either each country's most populated city or its capital (Mayer and Zignago, 2011).

[24]In a panel data framework, however, we use *exporter-time* and *importer-time* fixed effects, as they also allow controlling for the time-varying component of MRTs (Olivero and Yotov, 2012).

specification would suffer from collinearity issues unless alternative solutions are introduced. Motivated by these challenges, Heid et al. (2021) proposed an identification strategy using intra-national trade data, and proved that the model can produce unbiased estimates in the presence of country-specific fixed effects. Their study focuses on measures that do not apply to domestic producers, such as MFN tariffs and the numbers of days to export a cargo to a specific country.

Our interest is in the principle of non-discrimination, and the fact that measures should not be disproportionate against foreign producers. Therefore, our variable of interest must measure the differential impact of policies affecting international and domestic trade. This methodological approach is verified by Beverelli et al. (2018), who estimate the effects of the quality of institutions on trade. The authors show that the model is also suitable when the policy of interest affects both domestic and foreign trade. Therefore, the benefits of using intra-national trade are twofold: it allows for an impact assessment comparison of food standards between local and domestic producers, and generates unbiased estimates. We exploit these findings to investigate the impact of food standards on international trade relative to intra-national trade in the presence of importer and exporter fixed effects, which should lead to a proper identification. Although this approach provides an intuitive interpretation of the discriminatory nature of SPS and TBT measures, Beverelli et al. (2018) explain that it does not allow for the direct identification of the impact of these standards on bilateral trade flows. The effect of the standards on trade, both domestic and international, is captured by the individual SPS and TBT dummies. Our model specification, thus, is as follows:

$$X_{ijpt} = exp[\beta_1 \ln \tau_{ijpt} + \beta_2 SPS_{jpt} \times I_{ij} + \beta_3 SPS_{jpt} + \beta_4 TBT_{jpt} \times I_{ij} + \beta_5 TBT_{jpt} + \beta_6 I_{ij} + \beta_7 Z_{ijt} + \eta_{it} + \mu_{jt} + \zeta_{pt} + \epsilon_{ijpt}] \quad (1.4)$$

where X_{ijpt} refers to bilateral trade flows from country i to country j of product p in a year t. The parameters of interest are β_2 and β_4, and they capture the relative effect of food standards on foreign producers with respect to local ones. For the sake of clarity, our coefficients do not appraise if the effects of regulation are positive or negative, but whether foreign producers benefit less from trade enhancing measures or are worse affected by trade-restrictive ones. This is captured by the individual dummies in β_3 and β_5. The main feature of our model is the interaction of SPS and TBT dummies capturing the presence of standards with I_{ij}, a dummy variable equal to one when there is an international border between the origin and the destination of goods and zero for domestic trade; τ_{ijpt} is one plus the lowest tariff as defined in section 3; Z_{ijt} is a vector of time-variant bilateral control variables that determine trade, including SPS and TBT provisions on trade agreements and the interaction of I_{ij} with year dummies; (η_{it}), (μ_{jt}) and (ζ_{pt}) refer to exporter, importer and product time-varying fixed effects, respectively; ϵ_{ijpt} is the error term. This model specification is the standard used for our panel analysis. In the cross-section analysis, we incorporate the classic gravity covariates –distance, language, common border and colonial ties– and use a simpler set of fixed effects.

This identification strategy lets us control for product and time variation. In this regard, the inclusion of tariffs is important as it is a prominent source of product-level heterogeneity. Figure 1.2 provides evidence of this variation, showing averaged tariffs across 23 agricultural HS headings. Import duties on beverages (mainly on spirits and wine) more than double the tariff levels on other products such as coffee or soybeans. Other products with high tariffs include meat, dairy products, tobacco, sugar and confectionery and food preparations that include soups, sauces and ice-cream. Differences are in some cases even more significant across products within the same 2-digit group.

Previous trade literature has shown that log linear models can lead to bias estimators. This is a particularly sensitive problem in the presence of zero values. Agricultural trade is

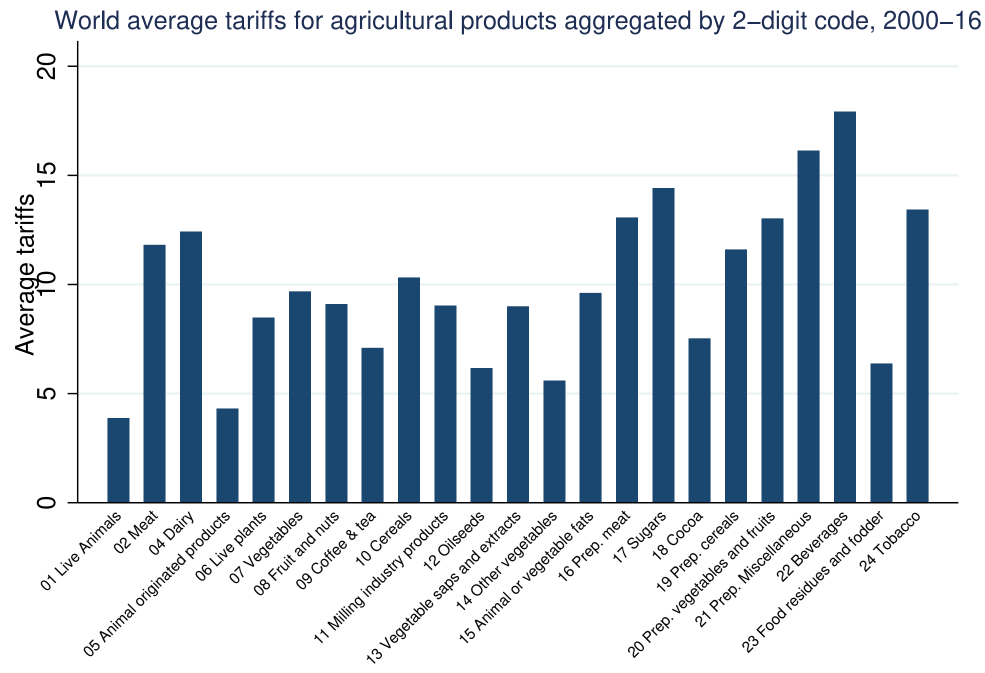


Figure 1.2: Tariff data obtained from World Banks's WITS database. Fish group (03) not shown as it is not included in our analysis. Aggregated 2-digit world values are authors' own calculations.

characterized by a large proportion of zero trade flows. For example, most fruits are produced in warm-climate areas, and therefore, exports of fruits from countries far away from the equator tend to be zero. Therefore, we estimate our model in a multiplicative form. As shown by Silva and Tenreyro (2006), the Poisson Pseudo Maximum Likelihood (PPML) estimator deals well with zero trade flows, and it is robust in the presence of heteroscedasticity, another common feature of agricultural trade.

1.6 Analysis of results

Analysis of heterogeneous effects between domestic and foreign producers

We start by reporting cross-section results in column (1) that will serve as a reference to compare with our panel data estimates. It also helps to verify a correct specification of the model by presenting the estimates for the standard gravity covariates. Unlike studies using exclusively international trade data, our *distance* variable also accounts for internal distance, assuming that consumers are uniformly distributed across the country's area (Mayer and Zignago, 2006). Yet, the results reported in Table 1.1 are in line with the existing literature, where bilateral distance –represented in logarithmic form– is a significant trade-restricting factor.[25] Intuitively, the perishable nature of agri-food products makes it very sensitive to distance and countries tend to trade with neighbouring trade partners when possible. The results for *contiguity* and *common language* variables also correspond with the usual estimates –positive and statistically significant–, while colonial ties do not seem to be a determinant factor for agri-food trade flows across the countries in our sample. This is related in part to former colonial nations once sharing markets now competing to supply the same agri-food products. For example, Australia and New Zealand's tradition as sheep meat exporters was forged during the British Empire (Higgins, 2004). Now, these countries compete with the United Kingdom for international market share. The negative and strongly significant estimates for the international border dummy show that countries prefer to trade domestically over foreign producers. Nonetheless, international trade increases when countries sign deep trade agreements. This is observed on the *FTA with SPS or TBT provisions* variable, which is equal to one when an international trade agreement incorporates provisions on SPS and TBT measures, such as harmonization or mutual recognition.

[25] See Disdier and Head (2008) for a meta-analysis of the "distance puzzle"

Table 1.1: Relative Effect of SPS and TBT Measures on International Vs intra-national Trade.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2283***	-0.1426***	-0.1437***	-0.1517***	-0.0551***
	(0.0389)	(0.0352)	(0.0363)	(0.0389)	(0.0071)
SPS × Int. Border	0.1607	0.2200	0.2240	0.1926	-0.1946
	(0.3341)	(0.2396)	(0.2584)	(0.2834)	(0.1429)
importer SPS measure	-0.2757	-0.2034	-0.2076	-0.1875	0.3408**
	(0.3214)	(0.2463)	(0.2602)	(0.2842)	(0.1429)
TBT × Int. Border	0.4154	-0.3119**	-0.3375**	-0.3330*	0.1137
	(0.3442)	(0.1583)	(0.1702)	(0.1769)	(0.1572)
importer TBT measure	-0.1786	0.1162	0.1336	0.1488	-0.0270
	(0.4687)	(0.1329)	(0.1455)	(0.1559)	(0.1585)
log distance	-0.2524***				
	(0.0651)				
contiguity	0.3906**				
	(0.1816)				
common language	0.4514***				
	(0.1107)				
colonial links	-0.0637				
	(0.1619)				
FTA with SPS/TBT prov.	0.3447***	0.0611*	0.0609*	0.0281	0.0407**
	(0.1017)	(0.0360)	(0.0350)	(0.0351)	(0.0172)
Int. Border	-3.6652***				
	(0.3848)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4099
Pseudo R-squared	0.8172	0.8542	0.8538	0.8504	
Number of observations	161,012	2,170,182	1,500,200	1,173,300	1,986,804

Note: Gravity estimation using data on domestic demand. Intra-national trade is accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. The dummy variable "FTA with SPS or TBT provisions" is equal to 1 when a trade agreement includes SPS and/or TBT provisions. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Columns (2) to (5) cover the panel data analysis. Except for column (5), that are OLS estimates, they are reported using the PPML estimator and the international border dummy is interacted with year dummies. All estimates include importer-time, exporter-time and product-time fixed effects. All regressions except for column (5) also incorporate country-pair fixed effects. Standard errors are clustered by country-pair doublet to capture any potential bilateral correlation in the error term (Yotov et al., 2016). The regression includes both SPS and TBT measures as they are not collinear. Tables A.3 and A.4 in Appendix A.3 confirm this by showing that the individual regressions do not alter the results. Overall, the results do not detect any significant impact on international trade relative to domestic trade in the application of SPS standards. These results can be interpreted as a good sign of non-discrimination and the principle of national treatment, where domestic regulation affects national and foreign producers in a proportionate manner. However, we do observe a decrease in international trade in favour of domestic one after the application of TBT measures. It is important to emphasize again that the results do not indicate whether regulation has a negative or positive impact on the market, as this is captured by the individual dummies –and which shows no statistically significance–. Instead, our interaction variables indicate whether the effect of regulation, either trade-enhancing or trade-distorting, affects differently to domestic and international producers. Therefore, we can determine that, while the overarching set of SPS measures affecting agri-food products does not show a differentiated impact on international and domestic trade flows, TBT measures favour domestic producers.

To confirm the validity of our results, we run the model over lagged periods, given that adjustments to regulation are not instantaneous (Yotov et al., 2016). Column (2) presents results in the year of introducing the measure, while columns (3) and (4) report results with one and three-year lags, respectively. Lagged regressions can be estimated either using continuous data or time-intervals. We opt for using annual data, as high-frequency information alleviates the probability of bias estimates and better present the dynamic adjustment to the implementation of new trade policies (Egger et al., 2020). The results are fairly consistent when including lagged periods. Regarding TBTs, we observe a slight increase in domestic trade relative to international flows the year following the introduction of a new measure, while producers adjust to the new regulations. The OLS estimator reports positive results for the impact of SPS measures. It is worth noting that in the OLS estimates, we add one dollar to the value of trade to transform it into a logarithmic expression.[26]. This approach, however, does not allow to properly exploit the information contained in zero trade flows. Finally, we include in the regression trade agreements that include SPS and TBT provisions, whether it is in the form of for mutual recognition, harmonization, or other commitments. These provisions have a positive impact on trade, but the effects vanish after the third year.

As expected, tariff estimates are negative and statistically significant throughout all regressions, posing a barrier to international trade flows. As for the dummy on SPS and TBT provisions, our model does not find any significant gain for international producers except in the OLS estimation. This is in line with previous studies that have found empirical evidence on the ambiguous effects of deep trade agreements. Disdier et al. (2015) find that provisions on standards have heterogeneous effects depending on the type of measure implemented and the countries involved. Overall, the authors observe a negative impact on developing countries' exports when they align their regulations with developed countries. These estimates should be taken carefully as they might be constrained by the border-year interaction variables. These variables are at the country-pair year level, which is where most of the action on trade agreements is observed. Indeed, the regressions where this interaction term is not included, that is, the cross-section and OLS estimations, yield positive and significant results from deep trade agreements on international trade.

The spike in food prices between 2006 and 2008 led many governments to reactivate

[26]We have used the Stata command *ppmlhdfe* in our PPML estimations as it is very flexible in the introduction of fixed effects (Correia et al., 2019). The Stata command for the OLS method is *reghdfe* (Correia, 2019).

Table 1.2: Comparison of food standards before and after food price crisis (reference year = 2008).

	(1)	(2)	(3)	(4)	(5)	(6)
		Pre-crisis			Post-crisis	
	No Lags	1-Year Lag	3-Year Lags	No Lags	1-Year Lag	3-Year Lags
log tariffs	0.0215	-0.0071	0.0059	-0.0214**	-0.0181*	-0.0434***
	(0.0247)	(0.0209)	(0.0437)	(0.0100)	(0.0101)	(0.0123)
SPS x Int. Border	-0.1342*	-0.0763	-0.0216	-0.1393***	-0.1344**	-0.0345
	(0.0761)	(0.0526)	(0.0487)	(0.0482)	(0.0533)	(0.0977)
TBT x Int. Border	0.0993**	0.1003*	0.1615***	-0.0113	-0.1205**	-0.2703***
	(0.0472)	(0.0586)	(0.0320)	(0.0550)	(0.0488)	(0.0822)
FTA with SPS/TBT prov.	-0.0302	-0.0221	0.0287	-0.0375	0.0024	-0.0281
	(0.0699)	(0.0565)	(0.0239)	(0.0260)	(0.0261)	(0.0293)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair product FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9984	0.9986	0.9988	0.9975	0.9977	0.9979
Number of observations	869,065	561,795	346,712	853,127	553,728	316,629

Note: Gravity estimation using data on domestic demand. All columns are reported using a PPML estimator and include importer-product-time and exporter-product-time fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt} and includes domestic demand when $i = j$. Pre-crisis period covers from 2000 to 2008, while post-crisis period goes from 2008 to 2015. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

plans to protect their local agri-food industry. Our database allows searching for drifts in food regulation after the price crisis, as governments might have had incentives to protect their local food industry. Initially, many countries reduced tariffs as a quick response to the price surge at the end of 2006, but once the period of high international food prices was over, many governments laid out intervention programs to ensure a strong domestic supply response and limit the exposure to international markets (Sundaram, 2010). A question still unanswered is if technical standards have also played a role in protecting domestic producers.

In the results reported in Table 1.2 there is evidence that shows a reformulation on the use of SPS and TBT measures. In the years before the food price crisis, the introduction of TBT measures favoured international trade flows and SPS measures had hardly any negative impact on foreign producers. The results show that the impact of standards on foreign producers has dramatically changed after the crisis, as reported in Columns (4) to (6).

Table 1.2 shows the results for the pre- and post-crisis periods. For reference purposes, the three columns reported for each period correspond to the columns from (2) to (5) previously reported in Table 1.1. Our results exhibit a clear trend lately towards more discriminatory measures. While SPS measures tend to affect exporters more negatively in both periods, the results are not very meaningful up to 2008. In the post-crisis period, however, there was a significant tendency to use standards that favour domestic food producers. The change in the use of TBT measures is even more remarkable. These technical standards facilitated exporters market access prior and during the crisis, but there has been a dramatic change recently. The results are worrisome for the good functioning of the current trading system. International producers are losing market access in favour of domestic producers, and these negative effects have increased over several years. These findings are also in line with the increasing number of concerns raised at the WTO. Therefore, although the aggregated effect of SPS and TBT measures reported previously in Table 1.1 appears to be non-discriminatory, food standards during the post-crisis period have limited the market access for exporters in favour of local producers. These findings suggest the need for a close monitoring of technical standards. Besides, they underline the need for renewed multilateral dialogue and commitments to ensure that new measures comply with the agreements that governments pledged to adopt. In sum, the results support Pascal Lamy's call for further attention and better understanding of the wide variety of non-tariff measures.

Next, we search for differences in the discriminatory nature of standards within the same type of NTMs. We separate the measures with no concerns from those that have escalated into an informal discussion at WTO meetings, classified as Specific Trade Concerns (STC). There are grounds to think that measures with concerns are trade-restrictive as trade partners require clarifications, or even modifications, over the implemented measure. In some cases, an STC is a step prior to a formally arbitrated dispute. But countries sometimes also raise their concerns at WTO even before the measure is implemented. For example, a new standard might not be sufficiently clear in the concept or product scope when first published. There are also cases of STCs raised long after a new standard is in place, as issues might arise during the compliance checking process.[27] Ideally, we would have separated the sample based on the timing of the concern raising and adjust the model accordingly applying the necessary lags. However, the sample is not large enough to allow this while keeping econometric robustness.

We investigate whether the allegedly trade-restrictive measures violate the principle of non-discrimination, and whether there is any difference with measures not perceived as a barrier by exporters. The results for SPS and TBT measures are reported in Tables 1.3 and 1.4, respectively. The results of the SPS variable suggest that, when looking at the whole group of SPS measures, the impact of trade is ambiguous and some measure might affect positively while other negatively. These results are in line with those reported in Table 1.1. However, the results are negative and strongly significant for the case of safety standards of concern, which means that domestic producers enjoy a better market situation after one of these measures is introduced. Again, for the bulk of measures without a concern raised at the WTO Committee, we do not observe a detrimental impact on foreign producers relative to nationals.

The case of TBT measures is substantially different, and we observe a higher level of heterogeneity. Local producers clearly take market share from exporters in measures with concerns. The results are negative, significant, and consistent across all regressions. We can draw a few conclusions from the results of both tables. First, the small group of measures with concerns holds most of the discriminatory effects derived from SPS and TBT measures. This argument is in agreement with De Melo and Nicita (2018a) who also found that a larger number of measures do not necessarily mean a more stringent market and the real difference is in the stringent nature of each measure. The indicator used to evaluate NTMs therefore

[27]According to WTO figures, 46% of STCs are raised in reference to drafted but, at the moment of raising the concern, not yet implemented measures. On the other hand, 32% of the STCs refer to measures implemented by country members without notifying to the WTO and trade partners (Possada et al., 2020).

Table 1.3: Differentiated impact of SPS Measures with and without Specific Trade Concerns.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2226*** (0.0372)	-0.1414*** (0.0350)	-0.1425*** (0.0360)	-0.1506*** (0.0388)	-0.0552*** (0.0070)
SPS with concern x Int. border	-0.7386* (0.4020)	-0.5643** (0.2587)	-0.5859** (0.2829)	-0.5385* (0.3016)	0.2302** (0.1152)
importer SPS measure	-0.3007 (0.3035)	-0.1451 (0.2144)	-0.1410 (0.2193)	-0.1134 (0.2312)	0.2915*** (0.1071)
SPS w/o concern x Int. border	0.2445 (0.3104)	0.2212 (0.2031)	0.2323 (0.2156)	0.2036 (0.2302)	-0.1480 (0.1060)
log distance	-0.2624*** (0.0645)				
contiguity	0.3634** (0.1792)				
common language	0.4250*** (0.1103)				
colonial links	-0.0413 (0.1620)				
provisions on SPS	0.4510*** (0.1143)	0.0681* (0.0377)	0.0734** (0.0364)	0.0377 (0.0363)	0.0399** (0.0180)
Int. Border	-3.2122*** (0.3382)				
Border*year dummies	no	yes	yes	yes	no
Country-pair product FEs	no	yes	yes	yes	yes
R-squared					0.4099
Pseudo R-squared	0.8174	0.8542	0.8538	0.8503	
Number of observations	161,012	2,170,182	1,500,200	1,173,300	1,986,804

Note: Gravity estimation using data on domestic demand. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

plays a crucial role in the final assessment. With this in mind, we can deduce that the prevalence score, which indicates the average number of measures applied per product, is not a good indicator to evaluate trade restrictiveness. Second, it shows that trade partners accurately identify if a measure can create a sizeable trade barrier. When they raise a concern about a specific rule at WTO committees, it seems well justified. Even if these rules address genuine market failures or consumer needs, they have been disproportionately tabled in terms of market access and should be amended. The group of measures that partners do not deem trade distorting tend to provide market access gains to international producers. A conclusion from these results is that, while the vast majority of TBT measures comply with the principle of national treatment, there is a small group of measures that affect exporters harshly and over several years.

Table 1.4: Differentiated impact of TBT Measures with and without Specific Trade Concerns.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2268***	-0.1421***	-0.1431***	-0.1518***	-0.0551***
	(0.0375)	(0.0353)	(0.0364)	(0.0390)	(0.0071)
TBT with concern x Int. border	-0.9077*	0.1181	0.2741	0.1939	0.1869
	(0.4685)	(0.2566)	(0.1798)	(0.2134)	(0.1233)
importer TBT measure	-0.2172	0.0633	0.0785	0.1018	0.1106
	(0.4731)	(0.0902)	(0.0937)	(0.0980)	(0.1185)
TBT w/o concern x Int. border	0.4550	-0.2301**	-0.2672**	-0.2648**	-0.0137
	(0.3438)	(0.1160)	(0.1181)	(0.1204)	(0.1159)
log distance	-0.2536***				
	(0.0668)				
contiguity	0.4054**				
	(0.1869)				
common language	0.4559***				
	(0.1084)				
colonial links	-0.0268				
	(0.1513)				
provisions on TBT	0.2659**	0.0562	0.0568	0.0164	0.0350**
	(0.1052)	(0.0369)	(0.0352)	(0.0345)	(0.0175)
Int. Border	-3.5601***				
	(0.3558)				
Border*year dummies	no	yes	yes	yes	no
Country-pair product FEs	no	yes	yes	yes	yes
R-squared					0.4098
Pseudo R-squared	0.8172	0.8542	0.8537	0.8503	
Number of observations	161,012	2,170,182	1,500,200	1,173,300	1,986,804

Note: Gravity estimation using data on domestic demand. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Analysis of heterogeneous effects between income groups

After evaluating the differentiated effects of regulation on foreign and national food producers, we go one step forward and search for the presence of heterogeneous shocks across trade partners. We build on the idea of Fontagné et al. (2015) that we should expect heterogeneous effects of trade-restrictive rules across exporters with different economic sizes. The authors use SPS concerns, as this database allows for the identification of measures that trade partners deemed as sizeable trade barriers. We expand this analysis to the whole range of SPS and TBT agri-food measures collected in the UNCTAD database, whether concerning or not. It is expected that standards tend to be more restrictive for exporters with limited resources to adapt their agri-food products, even if trade partners do not complain about the measure. Tables 1.5 and 1.6 show, results for SPS and TBT measures, respectively. In this new set of regressions, we replace the international border dummy by a "cross-group" dummy, equal to 1 when there is trade between countries from different income groups. For example, columns (1) and (2) estimate the effects of technical measures imposed by high-income countries. Note that we keep the observations for domestic trade. For example, the EU is represented as one single trade partner and its intra-trade belongs to the high-income group. The interaction now measures the effect on upper-middle, lower-middle and low-income exporters, relative to the effect on trade across countries within the high-income group. There is also a change in the FTA dummy variable in each regression table. It now controls for the presence of a provision in the corresponding measure. Beyond these modifications, the model is similar to the previously reported.

The results of the regression for the SPS measures suggest that the regulation imposed by developed economies is the most restrictive for the other income groups, with a coefficient of -0.0914. Columns (3) and (4) identify the measures imposed by high- and upper-middle-income economies. These results further highlight the negative and significant effects on vulnerable farmers and food manufacturers that arise from the imposition of food standards by high-income countries. These results help to explain why developed nations might be so inclined to maintain high food standards. On the one hand, consumer groups want to preserve high levels of food safety. On the other hand, farmer unions see food standards as a

Table 1.5: Aggregated effect of SPS Measures imposed by a group of countries from an income group over countries of different income level.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper-middle		Low and Lower-middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0162	0.0017	-0.0163*	-0.0172	-0.1656***	-0.1072***
	(0.0100)	(0.0126)	(0.0090)	(0.0106)	(0.0316)	(0.0350)
SPS × cross-group	-0.0914***	-0.0569	-0.0770***	-0.0544**	-0.0031	0.1764***
	(0.0323)	(0.0366)	(0.0259)	(0.0247)	(0.0922)	(0.0680)
Provisions on SPS	0.0263	0.0660**	0.0349	0.0647**	0.1594**	-0.2449
	(0.0255)	(0.0276)	(0.0243)	(0.0256)	(0.0644)	(0.1515)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9952	0.9955	0.9955	0.9951	0.9992	0.9991
Number of observations	950,771	736,310	1,106,158	853,293	179,063	127,541

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. The column headings identify the country-group imposing the measure. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

way to protect their market share. Such alignment may lead to the creation of lobbies such as the *Save Our Standards* initiative, created by British food producers, consumers, and experts with the aim of discouraging the UK government to sign new trade agreements that allow the entry of products with lower standards into UK food markets. By contrast, measures imposed by the lowest income economies tend to favour exports from advanced economies in the long run.

The results on the TBT measures are more ambiguous. We can conclude that again, exporters from high-income countries face lower compliance costs to adapt to new requirements and benefit when measures are imposed in less developed economies. The fact that we do not observe significant results for the case of standards imposed by high-income economies could be explained because these measures also negatively affect exporters from developed nations. The scope and nature of these standards are also often determined by the influence of lobbyists and trade disputes. The tobacco industry is a commonly known example of an industry lobby influencing tobacco-control measures. This is the case of Philip Morris' pressure on US trade authorities to hinder Canada's plain packaging measures based on

Table 1.6: Aggregated effect of TBT Measures imposed by a group of countries from an income group over countries of different income level.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper-middle		Low and Lower-middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0143	0.0022	-0.0156*	-0.0161	-0.1628***	-0.1178***
	(0.0101)	(0.0126)	(0.0091)	(0.0106)	(0.0319)	(0.0337)
TBT × cross-group	0.0350	-0.0100	0.0669**	0.0342	-0.0817	0.1951***
	(0.0329)	(0.0240)	(0.0272)	(0.0270)	(0.0599)	(0.0624)
Provisions on TBT	0.0377	0.0736***	0.0468*	0.0712***	0.1892**	-0.1175
	(0.0257)	(0.0267)	(0.0244)	(0.0248)	(0.0737)	(0.1391)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9952	0.9955	0.9955	0.9951	0.9992	0.9991
Number of observations	950,771	736,310	1,106,158	853,293	179,063	127,541

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. The column headings identify the country-group imposing the measure. Standard errors are clustered by country-pair. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

concerns about the Agreement on Technical Barriers to Trade (McGrady, 2011b). Similarly, Sebrie et al. (2005) explain that the national law of tobacco control in Argentina related to advertising and packaging is so weak due to the influence of industrial powers.

The estimates of the regression by food group also offer interesting findings. Table A.1 and Table A.2 in Appendix A.2 present the results for the specification with one and three-year lags, respectively. For standards within the SPS group, the largest differences observed between local and foreign producers are in Columns (1) and (5) for the groups that encompass products of animal origin -including live animals, meat and dairy- and the group of remaining products -which includes, among others vegetable oils, sugars, and food preparations-. Only in these two groups the impact of a new SPS is significant, and it shows a positive impact on trade flows particularly after three years of its implementation. However, local producers benefit remarkably more than exporters, absorbing market share. The results are non-trivial, given that a great share of new SPS measures are imposed in products of animal origin. As for TBT, we observe the same dynamic in the fruits sub-sector, in column

(3), in the first year after implementation, with domestic producers enjoying relative market gains. Cereals, products of animal origin and other products show a negative reaction to a newly introduced TBT. The negative impact is absorbed equally by local and foreign producers both for fruits and the animals and byproducts sub-sectors. However, there is a strong and significant relative gain for international producers in the group of multiple products. In other words, international producers gain market share even if the volume of trade flows might decrease. Interestingly, the industry of live plants and vegetables shows no sensitivity to the introduction of a new standard, both in terms of overall market effect and potential disparity in the impact across producers.

In general, our findings are consistent with previous studies on specific types of measures or specific countries (Disdier et al., 2008; Essaji, 2008; Murina and Nicita, 2017; Nicita and Seiermann, 2016). Our results suggest that technical standards create trade cost asymmetries and, if not controlled, can exacerbate market access inequalities. It is necessary to ensure that agri-food producers from developing and least-developed nations do not see their market access hindered by standards. Many agri-food producers rely on exports as their major source of income. We thus present similar findings to Nicita and Seiermann (2016), and conclude that WTO's Trade Facilitation Agreement Facility, and other efforts to provide technical assistance to low-income countries are essential to guarantee market access in developed countries. Developing countries can also combine international efforts with other domestic policies, such as producer cooperatives, where they can share information and unite capacity building efforts on regulatory compliance.

Analysis of heterogeneous effects across trade partners

Finally, we contribute to the understanding of the more stringent regulation: STCs. We examine whether the trade-distorting effects are homogeneous across foreign producers or, instead, there are differences between countries raising a concern, those supporting the concern, and the ones that are not concerned. We rely again on the predictive power of the gravity model. The specification varies slightly with respect to the previous approach. Intuitively, we do not keep domestic trade data as it might bias our results. A WTO member is not expected to condemn itself about a new regulation. At the same time, if the measure is trade concerning, the member might be seeking to provide a competitive advantage to its local producers. Therefore, we do not need to interact our variable of interest with an international trade dummy. Our new variable, the trade partner reaction to a measure, is now bilateral by definition. We can identify the treatment effect equal to 1 when an exporting country i is concerned about a measure imposed by an importer j:

$$X_{ijpt} = exp[\beta_1 \ln \tau_{ijpt} + \beta_2 STC_{ijpt}^{reaction} + \beta_3 PROV_{ijt} + \phi_{ipt} + \gamma_{jpt} + \epsilon_{ijpt}] \; \forall i, j \quad (1.5)$$

where $STC_{ijpt}^{reaction}$ refers to a country's response to a new SPS or TBT measure. The reaction can be in the form of a concern, either raising it or supporting it at WTO special Committees, or by not being concerned. $PROV_{ijt}$ identifies the presence of SPS or TBT provisions in an existing agreement under which both partners trade. ϕ_{ipt} and γ_{jpt} are *exporter-product-time* and *importer-product-time*, respectively.

We compare the three different groups in the results presented in the next page. To facilitate the interpretation of the results, they are presented in three different tables. Table 1.7 compares the effects of stringent measures for countries that have publicly raised their voice at WTO meetings, either by raising or supporting a concern, and those that have not been involved.[28] We estimate the equation for one, three and six year lags. The reasoning behind is that the average time to resolve a concern is five years. We should thus expect that,

[28]Note that countries that not raised might still be concerned about the measure, but they might have a reason to take no action. For instance, the exports to that country might be small, or they might also have similar stringent measures in place.

overall, measures are not trade-restrictive once the five-year period has passed. As one might predict, our estimates project a more harmful impact on countries concerned. The negative effect is immediate and last briefly. In concerns related to TBT measures, the impact is stronger and expands to the year after the concerned is raised. The negative effects water down over time and after the fifth year, we even observe a trade-enhancing effect for TBT measures.[29]

Table 1.7: Differentiated Effects of SPS and TBT measures on concerned Vs non-concerned partners.

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0189*	-0.0275***	-0.0290***	-0.0368***	-0.0273***
	(0.0107)	(0.0103)	(0.0109)	(0.0122)	(0.0094)
SPS with concern	-0.0599**	-0.0279	0.0165	0.0033	-0.0088
	(0.0300)	(0.0286)	(0.0268)	(0.0301)	(0.0267)
TBT with concern	-0.1103***	-0.0653***	-0.0207	0.1947***	0.0082
	(0.0311)	(0.0218)	(0.0226)	(0.0355)	(0.0224)
FTA with SPS/TBT prov.	0.0416	0.0637**	0.0669***	0.0643**	0.0661**
	(0.0271)	(0.0272)	(0.0242)	(0.0283)	(0.0270)
Country-pair product FEs	yes	yes	yes	yes	yes
R-squared					0.9086
Pseudo R-squared	0.9887	0.9895	0.9905	0.9920	
Number of observations	853,150	644,483	522,909	378,971	803,100

Note: Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product p level from country i to country j in time t, X_{ijpt}. All columns include importer-exporter-product fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Next, we test the existence of heterogeneous effects within the concerned group of countries.[30] Due to the lack of information on supporting members for TBT measure, the results presented in Table 1.8 refer only to SPS concerns. The estimates signal a much stronger backlash on countries raising the concern. These findings ratify the theory that countries supporting a concern are not so deeply involved in the dispute (Horn et al., 2013). Finally, we carry out the same analysis to compare countries supporting a concern and those not involved in the dispute (Table 1.9). The results are not significant and confirm that the

[29] Note how the effects of deep trade agreements play out in a completely opposite direction. The benefits from trade integration take almost a year to be relevant, but once it kicks in, they last long.

[30] The variable *Country Raising* is equal to 1 when the exporting country i has raised a concern, and 0 if it is supporting it.

Table 1.8: Differentiated Effect of SPS measures on countries raising Vs countries supporting a concern

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0127	-0.0210	-0.0073	-0.0193	-0.0259**
	(0.0143)	(0.0135)	(0.0145)	(0.0142)	(0.0124)
Country Raising	-0.1006***	-0.0601**	0.0191	-0.0225	-0.0156
	(0.0278)	(0.0279)	(0.0286)	(0.0337)	(0.0258)
provisions on SPS	-0.0626*	-0.0367	-0.0134	0.0420	0.0120
	(0.0357)	(0.0358)	(0.0322)	(0.0400)	(0.0344)
Country-pair product FEs	yes	yes	yes	yes	yes
R-squared					0.9111
Pseudo R-squared	0.9869	0.9878	0.9889	0.9904	
Number of observations	491,042	367,015	295,740	213,528	464,022

Note: All columns include importer-exporter-product fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table 1.9: Differentiated Effect of SPS measures on countries supporting Vs countries not concern

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0242***	-0.0286***	-0.0296***	-0.0272***	-0.0370***
	(0.0080)	(0.0084)	(0.0090)	(0.0097)	(0.0052)
Country Supporting	-0.0226	-0.0340	0.0038	-0.0143	0.0035
	(0.0280)	(0.0279)	(0.0286)	(0.0293)	(0.0309)
provisions on SPS	0.0070	0.0204	0.0045	-0.0121	0.0326*
	(0.0208)	(0.0208)	(0.0217)	(0.0406)	(0.0188)
Country-pair product FEs	yes	yes	yes	yes	yes
R-squared					0.8968
Pseudo R-squared	0.9849	0.9866	0.9879	0.9898	
Number of observations	1,858,342	1,285,996	992,608	698,650	1,728,872

Note: All columns include importer-exporter-product fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

barriers to trade created by regulation tend to be concentrated on a small group of countries (or a single country) raising the concern.

We can conclude that measures subject to concerns have a stronger negative impact on trade partners than any other notified measure. This impact is strong, immediate, and highly concentrated in a small group of countries. These are the countries that normally raise concerns at WTO meetings. Such a highly concentrated effect raises new questions about the use of regulation as a protectionist measure. Domestic regulation introduced with the genuine purpose to protect the health of consumers, animals, plants, or the environment might have negative spillover effects on international trade, but we might expect that such effects are homogeneous across trade partners.

1.7 Robustness Tests

As explained in Section 4, some data limitations require conducting further analysis to present robust results. We start by conducting a series of internal validity tests that compare with the regression in Table 1.1. Initially, we deal with the issue of potential correlation between SPS and TBT measures and how this could affect our results. A.3 introduces the results for both types of measures separately as in the model specified in Equation 1.4. Tables A.3 and A.4 show that the coefficients do not change in sign and significance. The analysis of the discriminatory nature of SPS measures remains inconclusive, while TBT measures favour domestic food producers. Appendix A.4 presents additional regressions dealing with issues we had to overcome in the data. First, we check that the presence of individual EU members is not creating biased estimates. The reasoning behind is that our SPS and TBT variables capture the presence of food standards between EU members. However, some of these measures are introduced at the EU level, while national-level standards tend to create low friction due to the in-depth integration of the Single Market. In other words, the FTA provision variable might not be able to capture the full integration of the Single Market, which could also be considered as domestic trade. This is a recurrent problem in the literature of non-tariff measures, and studies tend to either aggregate EU data or eliminate intra-EU trade (Disdier et al., 2008; Nicita and Seiermann, 2016; Murina and Nicita, 2017). In Table A.5 we replace EU members by the EU aggregate, to confirm that the results are not biased by the weight of intra-EU trade flows. An important difference with results in 1.1 is that we have no data on the internal distance for the EU aggregate. The model yields similar estimates to those reported in Table 1.1. There are no significant effects on SPS and slight positive effects for international producers relative to domestic ones when a TBT measure is imposed.

Table A.6 is estimated using the readily available UNCTAD database. This database provides a wider country coverage, including some important players in international agri-food markets, like Latin American countries. However, it lacks the variable that identifies measures applied domestically. This information is of special relevance in the assessment of non-discriminatory measures, and we have not used the UNCTAD data file in our main results for this reason. The estimated parameters are yet in line with our main regression, just slightly increasing the positive effect of TBT measures. The next test is of special relevance, given the difficulty to convert FAOSTAT product codes into HS equivalents. We applied simple averages in those cases where a single FAOSTAT code corresponded with multiple four-digit HS codes.

Table A.7 shows the results for the sample of product codes where there is a full correspondence between the two product classifications, and we are certain that the four-digit trade flow data is completely accurate. Again, the results are consistent with previous estimates. The positive effect for international exporters from TBT measures is stronger and significant after a three-year lag. SPS measures remain non-significant. We run the same test to support the findings reported in Tables 7 to 9. This data restriction halves our regression sample, but we make sure that not measurement errors are generated in the product code conversion process. In this case, the figures still support our main findings (Tables A.9, A.10 and A.11).

The last table in Appendix A.4 replaces the import-weighted tariffs with simple average tariffs. Both types of tariffs have their advantages and disadvantages when measuring their effects on trade. While weighted tariffs assign more relevance to tariffs imposed on highly traded products, they might underestimate the distortion created by high tariffs (Yotov et al., 2016). If we expect from highly stringent NTMs to have effects similar to those from tariffs, it is appropriate to test our model using simple averaged tariffs. The results, again, are consistent with previous estimates.

Results in Appendix A.6 verify that our selection of measures does not lead to bias results. In the previous section, we introduced the results based on a sample of NTMs that apply to local producers, but also measures with an unknown scope of implementation. This sample is preferred because otherwise we would be leaving out a considerable number of measures. Despite the majority of NTMs affect the domestic market, we check that our results do not change if we sample only those measures that have the certainty to be affecting local food producers (UNCTAD & World Bank, 2018). We report results comparable to tables 1.1, 1.2, 1.5 and 1.6. The figures are highly consistent with the previous section. There are only certain differences in Table A.15, the income-group analysis of TBT measures. Unlike previous estimates in Table 1.6, in this case we cannot determine if food standards imposed by low-income countries favour imports originating from the most developed economies.

Frequency ratios are an alternative to dummy variables used in the literature of NTMs. A frequency index measures the share of traded products subject to at least one NTM. On average, the agri-food industry presents the highest frequency in the economy, with more than 80% of products affected by at least a measure at the HS6 level (UNCTAD & World Bank, 2018). The figures comparing to Table 1.1 vary significantly. In this case, SPS measures are reported as favouring international producers relative to domestic producers, while the results on TBT measures are statistically insignificant. An explanation to the observed differences might be that frequency ratios ratchet down the presence of NTMs. This is a consequence of the data collection process designed by UNCTAD, which excludes partially covered measures (see Rial et al., 2019, for a further explanation on the collection on NTMs). Note that, when we use dummy variables, the NTM incidence is adjusted upwards. That is, we assign the value of one and assume that affects to all products under that four-digit heading. This approach might not necessarily be accurate to the real implementation of the measure. The outcome of the regressions on the temporal and income analyses, reported in Appendix A.7, is fairly consistent with the main results.

1.8 Conclusion

The study of technical measures using gravity equations has often suffered from methodological challenges. The necessity to include country-specific fixed effects to control for the multilateral resistance term was leading to collinearity problems. We exploit a new approach proposed by Heid et al. (2021) that allows for correct specification thanks to intra-national trade flows. Incorporating domestic trade allows the exploration of the (non-)discriminatory nature of SPS and TBT measures. In particular, we estimate the relative effect of technical measures on exporters compared to local producers for the period 2000 to 2015. This is done by interacting the presence of a regulation with an international border dummy at the country-pair level. Overall, we cannot establish that phytosanitary standards have a more stringent impact on international producers. In other words, we do not observe a generalized discriminatory nature in the bulk of SPS measures included in our study. This is not the case for TBT measures, as international producers lose market in favour of domestic producers. A closer analysis of their evolution over time projects more reasons for concern. We observe a trade-restrictive trend in the use of technical standards after the food price crisis that goes in line with the raising number of concerns recorded by WTO Committees. Curb down this trend should be a priority to exploit the benefits of the gradual elimination of tariffs. Any gain from tariff reduction is diminished by the proliferation of standards distinctively to foreign producers. Furthermore, we compare measures with and without concern using the STCs database. While we do not observe significant trade restrictions from the latter, we can indeed appreciate relative gains for local producers when a concerning measure has been introduced. A conclusion from these findings is that the prevalence score might not be a good indicator of trade restrictiveness. A product with many rules may face fewer barriers to international trade than another with one trade-restrictive measure.

Our second contribution is on the market access implications of NTMs. This time, we interact the SPS and TBT dummies with income country-group dummies to test for differences across income levels. Measures imposed by high and low-income countries have totally opposing effects. The evidence from the results suggests that, on average, low-income countries tend to lose market access relative to high and upper-middle economies when new rules on food products are imposed. These findings imply that monitoring and evaluation of NTMs, and particularly SPS and TBT measures, should continue, and it needs to be supported by other actions. Trade facilitation addressed to developing and least-developed countries should continue, and these countries might also consider the introduction of domestic policies to strengthen food producers' capacity to adapt to new production requirements.

Finally, we expand the literature on the heterogeneous effects of food standards by assessing the diverse impact of measures reported as trade-restrictive -STCs- across three different groups of trade partners: countries raising a concern, countries supporting the concern and countries not concerned. The stringent impact of SPS concerns is concentrated in the small group of countries that raise them at WTO meetings. The immediateness, strength, and high concentration of trade restrictions raise questions about the underlying objectives of certain regulations. Spillover effects from standards designed with the genuine purpose to provide rigorous human, animal, plant, and environmental protection might create widespread barriers to international trade, rather than a protectionist-like targeted impact. These results are fairly consistent with a series of sensitivity analyses presented in the previous section. Nonetheless, the results should be interpreted with caution. Evidence from the existing literature shows that findings over the impact of NTMs on trade are heavily dependent on the methodological approach, and particularly dependent on the NTM proxy (Santeramo and

Lamonaca, 2019). For instance, results using *ad valorem equivalents* and frequency ratios tend to show a negative impact on trade, while studies using dummies show more ambiguous results. Santeramo and Lamonaca (2019) explain that these differences inherit from the distinct nature of the variables used in the model. For example, *ad valorem* equivalents calculated for NTMs are set out to capture the trade costs associated to a measure and thus more suitable to measure the intensive margin of trade. By contrast, dummy variables and indices are more suitable to proxy the impact in the extensive margin of trade by comparing across products with and without NTMs.

We have addressed and discussed some limitations of our dataset in the robustness section. However, there are still two matters to consider that are as many avenues for research. As presented in Section 4, the first is our extension of the newly introduced measures throughout our period of analysis, otherwise notified. This approach imposes strong assumptions in our panel setting, leading to a potential problem of measurement error. A better tracking of domestic regulations over time would substantially benefit the analyses of NTMs in a panel data context. The second issue is that UNCTAD database only collects information on public standards. There is an increasing trend in the use of private standards across the sector. In the agri-food industry, supermarket chains might demand high-quality standards, particularly for fresh foods. Due to the lack of available data on private standards, the existing literature is mostly based on cross-section and case studies (Beghin et al., 2015). However, this opens a new window for further research that can provide better external validity using information from the private sector.

Chapter Two

Sweet deals, heavy costs? The effects of food trade liberalization and diet-related health costs.

Abstract

The new trade agenda has changed the traditional focus on the impact of farm policies on international markets towards the implementation of policies tackling other market inefficiencies further down the supply chain. On the demand side, food security is no longer the only objective and the global mission is now to provide affordable healthy foods for everyone. Despite the trade-nutrition linkage gaining attention, unhealthy foods including snacks, other highly processed foods, and soft drinks that are widely associated with obesity, are generally ignored in trade negotiations. At the same time, the increasing economic burden of non-communicable diseases, where obesity is a major risk factor, is putting pressure on public health budgets. While trade and investment liberalization has pushed food prices down and provided access to a wider range of fruits and vegetables, it is important to determine the extent to which international expansion of processed foods has contributed to high levels of obesity and increasingly overweight populations. In this study, we examine how free trade agreements affect obesity-related healthcare costs through international inflows of unhealthy foods and soft drinks, and the net investment position of US food companies in Latin American markets. We test these mechanisms in a regression analysis based on the mediation approach, which tests for indirect effects. Firstly, we estimate the public health costs associated with obesity for a set of Latin American countries. Then, we use this measure of cost as the dependent variable in a regression analysis that examines whether trade agreements with the US, the largest producer of processed foods, have contributed to increased obesity costs. Our results provide evidence that Free Trade Agreements with the US promote the importation of unhealthy food products and substantially contribute to the rising economic burden of obesity. The figures for capital flows also show a significant but less strong impact on obesity costs. However, both effects are partial, implying that there are other underlying factors stimulated by FTAs that affect obesity costs.

2.1 Introduction

The world is putting on weight. According to the latest figures published by the World Health Organization (WHO), more than 1.9 billion adults, 39% of the population over 18 years of age, were overweight in 2016. This figure includes obese people, which represents 13% of the adult population worldwide, with females having the highest rates of obesity. In 2000, less than 9% of the world population was obese, and since 1975, the prevalence of obesity has expanded threefold. The rate of increase in obesity has been particularly high on the American continent, which has overtaken Europe as the most obese region in the world. Therefore, the focus of our study is on this part of the world.

Obesity can have severe consequences for health. The WHO considers excess weight a major risk factor in the development of chronic diseases -also known as non-communicable diseases (NCDs)- mainly type 2 diabetes, cardiovascular diseases, and some types of cancer. The WHO reports that NCDs cause 70% of total deaths in the world and can, therefore, have a significant negative impact on people's well-being.[1] NCDs also absorb a large share of public health budgets. Bloom et al. (2012) have estimated the worldwide cumulative cost of NCDs as USD 47 trillion for the period 2010-2030. There is therefore considerable interest in understanding the underlying factors contributing to the proliferation of NCDs. Kickbusch et al. (2016) propose a roadmap on how NCDs develop and consider international trade, along with a rising demand and expanding corporate outreach, as the three fundamental drivers. The focus of this paper is on the economic burden on the public health system associated with obesity and trade liberalization. In particular, we examine the role that trade agreements between the United States and Latin American countries have played regarding this issue.

[1] This figure represents around 40 million deaths each year. The leading causes of mortality are, in this order, cardiovascular diseases, cancers, chronic lung diseases and diabetes.

The first contribution of this paper relates to the estimation of obesity costs. Previous studies have focused on the economic burden of a single disease (Barcelo et al., 2017; Gheorghe et al., 2018) or the costs of obesity for a single country.[2] Only a few studies such as Fernández et al. (2017) that involve the participation of multiple national and international organizations collecting large amounts of data have been able to estimate and compare obesity-related costs. However, the method employed is not reproducible and the unit cost data unfeasible to collect the larger sample of countries in our study. We, therefore, simplify the method used by Fernández et al. (2017) to estimate obesity-related direct costs borne by the public sector adjusting the cost of illness using the approach from Rtveladze et al. (2014) and the attributable fraction developed by Steenland and Armstrong (2006). We generate, to the best of our knowledge, the first comparable obesity costs for a selection of Latin American countries.

We propose an approach that is used in other disciplines, but less commonly in trade policy research, to identify the effects of international trade agreements signed between the US and Latin American countries on increasing obesity costs over several years. Trade agreements may affect obesity in multiple ways, but we are interested in the effect *mediated by* imports of unhealthy food and drinks. As Sobel (1982) and Baron and Kenny (1986) explain, a mediated effect can also be defined as an indirect effect. A mediated outcome occurs when the effect of an independent variable on a dependent variable is either fully or partially mediated by another variable, the mediator. We therefore contribute to understanding the mechanisms through which trade agreements can affect food environments and, consequently, harm people's health and government budgets eventually. Finally, by regressing obesity costs on US net investment position in the food sector, we contribute to a better understanding of

[2]For studies on the economic burden of obesity see (Tremmel et al., 2017), as it arranges a summary of findings based on the timeframe, methodological approach and assumptions used.

the role of foreign investment on changing domestic food systems.[3]

The results show a partial mediation effect of free trade agreements (FTAs) on obesity costs through imports of snacks and soft drinks from the US and, to a lesser extent, US net investment in the food manufacturing sector. By "partial" we also acknowledge that the set of mediators does not cover all factors affecting obesity, and there are other drivers beyond those included in our model. One such factor is the sub-industry of food distribution, which is not included in our model due to the lack of available data. Among the policy recommendations we propose, we consider the incorporation of consumer protection provisions that ensure the nutritional value of food products entering into the domestic food system to be of paramount importance.

The paper is structured as follows. We divide Section 2 into two parts. First, we review the different ways that have been used to calculate obesity-related healthcare costs, and then summarize previous findings on the relationship between international trade, food consumption, and obesity. Section 3 outlines the data and methods, first discussing the cross-country estimation of obesity costs, then describing the regression analysis. Section 4 provides an analysis of the results, Section 5 provides the sensitivity analysis. Section 6 concludes.

2.2 Literature Review

Understanding the causes and consequences of obesity has become a priority in the fields of health and food. Adiposity is a very complex matter and there are multiple factors

[3] The international investment position accounts represent a statistical balance sheet between the United States and the world. The Bureau of Economic Analysis defines the international investment position as the accumulated value of U.S.-owned financial assets in other countries and U.S. liabilities to residents of other countries at the end of each period. The difference between assets and liabilities is the US net international investment position.

directly or indirectly contributing to the growing obesity and overweight figures. In simple terms, people gain weight when the energy balance is positive. That is, the energy intake -through food consumption- exceeds energy expenditure, which mostly depends on the energy requirements of basic functions in our organism and the amount of physical activity in a day. Both trends in energy intake and energy expenditure have been changing rapidly across the globe since the early 90s (Popkin and Gordon-Larsen, 2004). While dietary shifts seem to be a determinant factor in developing countries, a more sedentary lifestyle, associated with the labour transition from the primary to the service sector, is a major cause of rising obesity in the developed world.[4]

The increase in obesity is, in turn, translating into a higher risk of suffering from multiple diseases. Fernández et al. (2017) show that type 2 diabetes and hypertension are the two major comorbidities associated with obesity and overweight. Kyrgiou et al. (2017) conducted a systematic review of previous studies searching for association between adiposity and different types of cancer, finding strong evidence of this association in 11 types. All these comorbidities translate into a heavy economic burden. These costs can be classified as direct or indirect. Our focus is on the direct costs assumed by the public health system.[5] We do not include private healthcare costs due to data limitations for individuals' expenditure on private insurance, medical treatment, and medicines.

Multiple studies have attempted to estimate both direct and indirect costs associated with obesity. Both Tremmel et al. (2017) and Kim and Basu (2016) provide recent systematic reviews and find that most studies use data for one year and, in some cases, do not even cover the whole set of age cohorts in the adult population. The second problem is that due to the large data requirements, studies tend to focus on a single country. This method provides an

[4]Popkin and Gordon-Larsen (2004) point out other factors contributing to the lack of physical activity, such as substantial growth in the time dedicated to mass media.

[5]Lehnert et al. (2013) classify indirect costs associated with productivity loss in four main groups: presenteeism (employees unable to work at full capacity), absenteeism or sick leave, disability (measured by short and long-term absence), and premature mortality.

accurate representation of a nations' population obesity cost estimates, but does not address empirical questions concerning cross-country comparisons of obesity costs.

Our estimation strategy is based on the cross-country strategy used by Fernández et al. (2017) based on the imputation of costs of illness for a set of comorbidities associated to obesity and overweight. However, we adjust the methodology as we do not have such detailed disease cost data for all countries in our analysis. This methodology differs from two other common approaches used to estimate obesity costs. The instrumental variable (IV) approach used in relevant studies such as Cawley and Meyerhoefer (2012) relies on national health survey data as the common instrument used is the biological weight of a respondent's relative. However, it is not possible to access a comparable national health survey at this level for a multi-year and multi-country study. An approach that allows for higher flexibility in cross-country studies uses the Disability adjusted life years (DALYs). However, this strategy combines the effects of morbidity and mortality, and therefore does not allow separating the direct costs of obesity.[6]

As noted, Kickbusch et al. (2016) defined a set of "commercial determinants", based on previous empirical studies, that directly harm the health of people. They consider internationalization of trade and investment a main driver in the growing consumption of processed foods and drinks. Previous research has identified trade liberalization as a major driver in food consumption changes, indicating that better monitoring of trade policies is required (Rayner et al., 2006). More specifically, researchers have found evidence that, with trade liberalization, countries shift away from cereal-based traditional diets and adopt energy-dense "Western" diets high in fats, salt, and sugars (Popkin, 2006; Thow and Hawkes, 2009; Moodie et al., 2013). In consequence, a rapid growth in the consumption of processed foods is observed. Key determinants on this shift are greater variety, affordability, and availability of products. At the same time, it is believed that changes in eating patterns as a

[6]See Bloom et al. (2012) for a detailed explanation on costs estimation using DALYs

consequence of trade alter the quality and nutritional value of a country's diet (Hawkes et al., 2012).

The impact of trade liberalization on the consumption of junk food in the American continent has drawn much of the attention.[7] Popkin and Reardon (2018) find that the food system transformation resulting from more open food markets is a ''double-edged sword". Food prices are lower and food is more affordable for everyone. Trade liberalization has also meant that many foods are now available in typically low-availability seasons, and has increased the overall availability levels of other non-seasonal products, such as those in the meat and dairy industry. However, it has also led to the privatization and internationalization of the whole food supply chain. Governments have gradually lost the ability to control the food system due to its complexity, and policies have narrowly focused on some public food safety and phytosanitary standards.[8] Hawkes et al. (2012) also suggest that foreign direct investment plays an important role in reshaping food environments, and state that further empirical analysis of this subject is needed. These issues have thus motivated the inclusion in our study of net investment position data. This is the best available proxy to understand the participation of US companies in Latin American food markets.

A growing body of studies have focused on the impact of The North American Free Trade Agreement (NAFTA). Mexico and the US have experienced a large integration of their food systems over the past two decades. NAFTA has largely enabled the US soft drink industry to expand its sales across the northern and southern border. Previous findings link NAFTA to an increase in sugar intake in Canada (Barlow et al., 2017) and Mexico (Clark et al., 2012). The low cost of sugar-sweetened beverages, SSB, has contributed to the increase in demand among Mexicans with lower food budgets. Low-income marginal areas with limited water supplies are price-sensitive, as their daily intake of liquids relies

[7]See Section 3 for our definition of junk food.

[8]Food companies have expanded the production of ultra-processed foods low on nutritional value over the years, with limited public intervention to regulate the quality of food systems (Fardet and Rock, 2020).

heavily upon purchases. The proliferation of cheap carbonated drinks in retail stores and restaurants have competed aggressively with water and other products for market share of soft drinks. According to Euromonitor International data, the increase in soda consumption among Mexicans is described as 'striking.' The country registers the largest volume of soft drink purchases in off-trade markets worldwide since 2010. Sales estimates in 2017 are roughly 180 litres per person.[9]

It is important to note that these studies are descriptive and there is a need for further empirical evidence. Giuntella et al. (2020) have assessed the impact of NAFTA on obesity prevalence in Mexican women between 20 and 49 years of age using an IV strategy. Other studies have investigated how changes in trade policies impact on the consumption of healthy and unhealthy foods using a partial equilibrium model (Seferidi et al., 2018; Seferidi et al., 2019). Other studies follow a broader approach, where changes in dietary patterns and obesity are the result of a compound of economic and social factors that originate in the process of globalization. Costa-Font and Mas (2016) relies on KOF Globalization indicators to assess the impact of the different globalization components in an IV model. Similarly, Oberlander et al. (2017) used the KOF index, but instead applied a grouped fixed-effects estimator.[10] However, to the best of our knowledge, no empirical study has yet carried out a cross-country analysis to address the question of the impact of trade and investment agreements on obesity.

[9]Popkin and Hawkes (2016) use this database in their descriptive study on the impact of SSBs on weight gain and obesity-related diseases. Euromonitor data provide the most accurate information in the consumption of soft drinks and other junk food. However, we discard to use this database because of its limited time availability.

[10]Both studies find that the social component of globalization takes up most of the weight on the growth in obesity.

2.3 Data and Methods

For clarity, we split this section into two subsections, where we explain the methodology and data used. First, we set out how we obtain our dependent variable: the cost of obesity. Secondly, we lay out the model specification, where we introduce the mediation analysis used in the calculation of the average indirect effects of trade on obesity-related healthcare costs. We cover 18 Latin American countries, all of them included in Barcelo et al. (2017). We obtain the diabetes costs necessary to construct our estimates from this study. The period of analysis is from 2000 to 2015. This is the time frame for which public health data sorted by disease were available.

2.3.1 Estimation of obesity costs

In order to assess the economic effects of US food imports on the public health system of Latin American countries, we first estimate the obesity-related healthcare costs. We follow the approach developed by Fernández et al. (2017), a large study carried out by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC, or CEPAL following the Spanish abbreviation). Unlike previous studies at the local or national level, CEPAL designed a methodology that allows for cross-country comparison between Ecuador, Mexico, and Chile. The first step is calculating the burden, $Burden^o_{m,t}$, of the overweight and obese (differentiated by o) for each morbidity m and for the year t, which is calculated as follows:

$$Burden^o_{m,t} = \sum_{j=1}^{n} Prev^o_{j,t} \times \frac{RR^o_{m,j} - 1}{RR^o_{m,j}} \times Pop_{j,t} \tag{2.1}$$

where $Pop_{j,t}$ is the size of each population cohort j in year t; $Prev^o_{j,t}$ refers to the aged-standardized mean estimates of the prevalence of obesity and overweight for each year in adults from 20 to 79 years of age. The data are from the Global Health Observatory of the World Health Organization (WHO), which calculates the BMI using measured height and weight from national, sub-national or local population samples.[11] It is also important to note that overweight individuals have a body mass index (BMI) ≥ 25 kg/m^2, and thus includes the obesity group (BMI ≥ 30 kg/m^2). In order to avoid double counting, we extract the percentage of obese individuals from the overweight group to define the overweight population.[12]. Relative risks, $RR^o_{m,j}$, are obtained from the Global Health Data Exchange GBD Results Tool.[13] Relative risks represent the ratio of probabilities, comparing the exposure of two different groups to a certain outcome. The relative risks used in our study compare the probability of developing each of the diseases included in the study in groups with a normal BMI and a population with a BMI higher or equal to 25 kg/m^2. The relative risks therefore provide useful information to identify the burden of each disease attributable to obesity and overweight.[14] The expression $RR^o_{m,j} - 1/RR^o_{m,j}$ is the *attributable fraction*, and represents the proportion of cases for each disease that would have not occurred in the absence of high BMI (Steenland and Armstrong, 2006). Thus, we are calculating with this approach the incremental costs associated to obesity and overweight. We cover the same twelve pathologies reported in Fernández et al. (2017), listed in Appendix B.1.[15] There are other pathologies associated with higher levels of BMI, including recent evidence on the higher severity of COVID-19 among overweight and obese patients (Lobstein, 2021). Therefore,

[11] Different weights apply to the different data sources -e.g., measured BMI data in national samples weights more than sub-national and local samples. The statistical model also accounts for rural-urban rates in each country, where differences in BMI can be substantial. A summary of the input data and methods can be found in Abarca-Gómez et al. (2017). For a detailed description of the statistical model, see NCD-RisC (2016).

[12] We refer to this group when we mention the overweight population hereinafter

[13] http://ghdx.healthdata.org/gbd-results-tool

[14] In order to separate the disease burden attributable to obesity, we adjust the Global Burden of Disease (GBD) data on relative risks following Fernández et al. (2017) "most conservative scenario", which is: $RR_{obesity} = 1 + (RR_{overweight} - 1) * 2$.

[15] The GBD dataset includes two diseases corresponding to cerebrovascular diseases: intracerebral and subarachnoid haemorrhages. There are also two types of osteoarthritis, affecting the hip and the knee. This explains why there are two more entries in our list.

it is likely that we are underestimating the direct public healthcare costs of obesity. We also apply the prevalence and relative risk to each cohort. These groups gather individuals into age categories spanning 5 years and differentiate by gender. The GBD database also provides information on the relative risks of suffering ischaemic heart disease and diabetes mellitus type 2 associated to a high consumption of sugar-sweetened beverages. We use this information to dig deeper into the burden of soft drinks on public health expenditure.[16]

Next, we incorporate the burden of disease obtained in equation 2.1 into the estimation of obesity costs. Note that we use the top-down approach, as we do not have detailed data on the multiple costs defining the overall costs associated with each disease. Instead, we determine the overall costs per case of a disease and multiply by the number of cases to obtain the figures at the national level. We determined the national cost allocation with the above-mentioned attributable fraction. As the focus is on the direct costs associated with obesity, we do not include generic costs related to the standard functioning of hospitals, or costs outside the health system, such as private transportation to a hospital or economic losses due to lower productivity and absenteeism at the workplace.[17] We compute the costs of obesity using the following expression:

$$CoO_t^o = \sum_{m=1}^{n} Burden_{m,t}^o \times \frac{CoD^{LAC}}{CoD^{USA}} \times CoI_{m,t}^{USA} \tag{2.2}$$

This estimation employs the method in Fernández et al. (2017) methods, as the IV approach proposed by Cawley and Meyerhoefer (2012) imposes too many limitations to be applicable to a cross-country panel data analysis.[18] However, we take an additional step

[16]GBD does not provide relative risks for the youngest age group, 20 to 24 years old, and it is excluded from the sample.
[17]For studies on obesity-related indirect costs, see Goettler et al. (2017).
[18]The authors take as instruments the BMI of the respondents' relatives, based on the assumption of the linkages between genetics and obesity. They use household survey data in the US. Household surveys are difficult to harmonized across countries, due to its different designs and temporalities.

to compensate for the lack of cost of illness data for our group of countries. As we do not have comparable information on the costs per case for each disease, we use data on the costs of diabetes in 2015 for each Latin American country from Barcelo et al. (2017), CoD^{LAC}, to calculate the relative costs compare to the US, CoD^{USA}. Then, we apply this ratio to each disease ($CoI^{USA}_{m,t}$) using US data obtained from the Bureau of Economic Analysis, which provides detailed information on the costs per case and year for multiple illnesses, from 2000 to 2015. Rtveladze et al. (2014) also use this approach to estimate the costs of different obesity morbidities in Mexico. A summary of the estimated mean costs by country for three different sets of diseases is reported in Appendix B.2. Due to the lack of data, our study does not include private household expenditures related to obesity, such as certain out-of-pocket expenses and medicines not covered by universal healthcare programmes, and medical insurance premiums charged to obese people.

2.3.2 Model specification

Research on the causal effects of obesity has gained prominence as the percentage of the overweight population has dramatically increased in the two last decades. However, the identification of causality is subject to difficulties. Many factors play a role in the obesity pandemic. Physical inactivity, overeating, genetics, dietary changes, eating habits, and psychological and interpersonal factors are reported causes of weight gain (Harvey et al., 2002). Previous studies have explored the direct effects associated with these factors individually. However, they might also be interconnected -e.g., we are prone to overeat or change our dietary patterns during stressful periods-, and at the same time, the indirect effect of other factors can change the relationships. The overall negative effect of trade liberalization on diets has also been discussed previously, with particular attention to Latin American countries (Clark et al., 2012; Giuntella et al., 2020; Thow and Hawkes, 2009). We aim to identify the indirect effects originating from trade agreements with the US –the largest producer of heavily processed foods and soft drinks– on obesity changes in the consumption of unhealthy products. The obesity problem has both societal and economic implications. We focus our study on the economic burden of obesity as a central objective in trade policy is generating economic benefits for the nation. If our hypothesis is correct and current trade policies are unable to limit access to imported unhealthy food, leading to higher rates of obesity in the long term, then governments could be implementing inefficient policies.

Our definition of ”junk food” is based on the NOVA food classification proposed by Monteiro et al. (2010). This classification groups together food items by the nature, purpose, and extent of the industrial process they undergo rather than in terms of nutrients and food types.[19] We choose the NOVA classification because it has been widely used in previous scientific research, and it is also the basis for the dietary guidelines in some Latin American countries such as Brazil and Uruguay (Monteiro et al., 2018). The NOVA system classifies food products into four groups. Our reference is the fourth group, which describes ultra-processed foods. The list of products included in our analysis, provided in B.1, is based on this group, with the exclusion of products not consumed by adults, like infant formulas and other baby food. As described in the previous subsection, our obesity cost estimates are based on the prevalence of obesity and overweight in the adult population. In total, we cover 105 six-digit product codes.

Figure 2.1 is the Directed Acyclic Graph (DAG) that visually represents the underlying structure of our causal model. The vector of pre-treatment covariates, X_i, contains all factors that can affect obesity in country i, while the output variable $Y(t)_i$ contains the previously estimated costs of obesity. The source of most of our control variables is the World Bank Databank. We use urbanization rates as a proxy for sedentary lifestyles. Per capita income normalized with purchasing power parity rates is factored in as food consumption preferences

[19]Note that there are multiple conceptual frameworks to classify food. Monteiro et al. (2019) reviews the six existing classification that put aside processed food, although one of them is a variation of the NOVA proposal.

are partly determined by the available budget. Previous studies associate educational level with food consumption patterns; thus, we incorporate the educational attainment variable. Government expenditure is highly correlated with public health budgets, so controlling for this variable eliminates bias from heterogeneity in the available budget allocation for healthcare services. Finally, we control for access to safely managed drinking water services, as this is a factor of special importance for the analysis of soft drinks import demand. A country with poor public drinkable water systems relies on bottled drinks, and the consumer might not necessarily opt for water once at the supermarket.

We assume that trade and investment agreements can generate a positive stimulus to combat obesity in two main ways: better health services as a consequence of technological progress and access to a wider range of health products and services. However, trade also can involve negative outcomes through a higher market availability of soft drinks and processed foods, as well as changes in the food environment through foreign investment from multinational food companies and fast food chains. Therefore, $M(t)_i$ is the set of mediator variables: imports of junk food and sugar-sweetened beverages, and US investment inflows into the food industry of Latin American countries. Note that X has both a direct and indirect effect on Y, where the latter is mediated by M.

Previous studies have focused on the effects of a potential variable X that causes obesity prevalence, keeping everything else constant. This approach exposes the direct link (ADE) $X \rightarrow Y$, but subsumes all the paths that lead to Y through intermediaries and other covariates (Pearl, 2001). The DAG shows that our model must be able to capture both effects, so policymakers can design policies that better control the undesired effects of trade. Uncovering indirect effects should provide a better understanding of those mechanisms that lead trade to generate higher obesity. This type of analysis is not possible with the common IV model. Therefore, we base our study on a causal mediation analysis that allows for the identification of the average causal mediation effect (ACME). The total average effect (TAE)

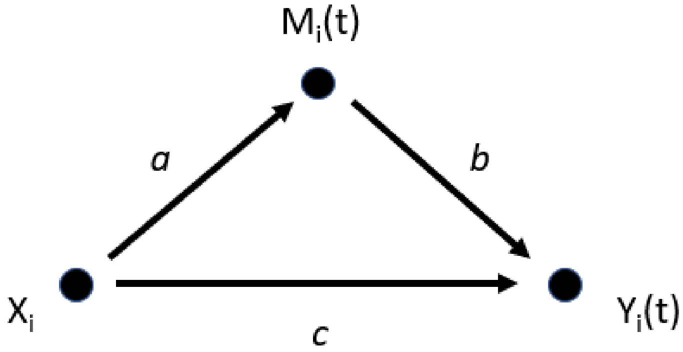


Figure 2.1: Directed Acyclic Graph representation of authors' model

can be expressed as follows:

$$TAE = ADE + ACME \tag{2.3}$$

Mediation analysis explores the underlying mechanisms observed in the relationship between a treatment (or exposure) variable t and the outcome variable Y, and assesses the role of the mediator in this relationship. This method has been widely used in psychology studies since the seminal work of Baron and Kenny, 1986 and has gained interest in social sciences more recently. Modern developments in mediation use a counterfactual framework for causal inference (Valeri and VanderWeele, 2013). This approach evaluates the mediation effect, whether the treatment (US trade agreement) is in place or countries trade under WTO rules. Causal mediation reduces potential bias caused by assumptions about confounders. Furthermore, a major advantage compared to traditional mediation methods is its ability to properly decompose direct and indirect effects even in the presence of an interaction between the treatment and the mediator (VanderWeele, 2016). In our study, it is logic to think that imports of junk food and soda are conditioned, no matter how, by the existence of a trade deal with the US.

Although it is not possible to determine the factors that generate a significant value for ACME, we expect it to be driven mainly by a price effect. Our treatment effect is a policy that liberalizes trade between the US and certain Latin American countries. Open trade facilitates access to the US production of snacks and soft drinks, while also can increase the price of certain healthy foods traditionally produced and consumed in Latin American countries due to higher export demand from the US.[20] With this in mind, our linear structural model of equations follows a similar approach to Imai et al. (2010a):

$$Y_i = \alpha_1 + \beta_1 T_i + \xi_1^\top X_i + \epsilon_{i1}, \tag{2.4}$$

$$M_i = \alpha_2 + \beta_2 T_i + \xi_2^\top X_i + \epsilon_{i2}, \tag{2.5}$$

$$Y_i = \alpha_3 + \beta_3 T_i + \gamma M_i + \kappa T_i M_i + \xi_3^\top X_i + \epsilon_{i3} \tag{2.6}$$

where the treatment variable T_i is a dummy variable equal to 1 if the country has a trade agreement in place with the US. We obtain the coefficients separately using the least squares regression in Equations 4 and 5. The expression $ACME = \beta_2(\gamma + \kappa t)$ represents the average causal mediation effect.[21]

Imai et al. (2010c) show that, for $\hat{\beta}_2\hat{\gamma}$ to be a valid estimate, the model needs to comply with the *sequential ignorability* –the $\top$ notation reflects this assumption in Equations 4 to 6– and no-interaction assumptions. The former assumption is split into two ignorability

[20] According to US Department of Agriculture, Mexican avocados represented more than 90% of total avocado imports in the US in 2021. This also represents around 80% of total Mexican avocado exports. The price of Mexican avocado has been continuously growing above inflation levels since 1994. In this period, the average consumption of avocados in the US increased sevenfold (https://www.nytimes.com/2018/03/27/magazine/the-fruit-of-global-trade-in-one-fruit-the-avocado.html)

[21] The regression analysis has been done using the R package developed by Imai et al. (2010b) and updated in Tingley et al. (2014).

assumptions for the treatment and mediator variables. First, the treatment assignment must be statistically independent (ignorable) from the mediator and outcome variables. In our model, we can be fairly certain that consumption of unhealthy food and the costs of obesity have little relevance when governments assess whether to negotiate new trade deals.[22] We can then conclude that causal mediation can be identified. Second, the mediator must be statistically independent based on the treatment status and the set of covariates introduced before treatment. In other words, changes in consumption of unhealthy foods must be independent of the X_i vector. Therefore, the mediator should be considered random among countries with similar characteristics that face the same decision about signing an agreement with the US. This is a strong assumption in our model, as there is a high possibility of unobservable confounders in the relationship between unhealthy food consumption and obesity-related healthcare costs, particularly in relation to difficulties establishing the monetary costs that the public health service incurs due to the consumption of junk food and sugary drinks. Nonetheless, Imai et al. (2011) propose a sensitivity analysis, that we discuss later, as this is a standard problem in many observational studies.

We also need to relax the original no-interaction assumption. In other words, we cannot assume that there is no link between the implementation of a trade deal with the US and changes in the consumption of unhealthy foods. Equation 2.6 has been adapted by incorporating the interaction term between the treatment and the mediator, as suggested by Chmura Kraemer et al. (2008). The authors state that at least one parameter between $\hat{\gamma}$ or $\hat{\kappa}$ must be statistically different from zero to conclude that there is a mediation effect.

[22]While there is an increasing pressure from NGOs and consumer groups on food quality and safety issues, up to now there has not been provisions in trade agreement texts that aim at controlling the access to unhealthy foods.

2.4 Results

Before presenting the results of the mediation model, we show the estimation of the linear regressions featuring both key relationships. The OLS estimates validate the feasibility of the mediation analysis and, at the same time, provide a clearer picture about the expected effects of the various covariates incorporated in the study. Table B.5 in Appendix B.3 shows how the set of control variables interplay with the mediator. As the mediation variable is the consumption of junk food resulting from the signature of new free trade and investment agreements, we have split the linear regression into three main potential outcomes affecting the food environment. The three linear regressions have the following dependent variables: imports of unhealthy food from the US, imports of soft drinks, and net capital investment flows in the food sector between the US and Latin American countries.[23] The first two variables are in logs, but we regress the investment data in levels because the net flows are negative in some cases. This helps to explain the disparity in the coefficients in column (3) with respect to columns (1) and (2). For clarity, this regression corresponds with path *a* presented in Figure 2.1. The most important result is that the coefficients for the main variable of interest, free trade agreements, are strongly significant. As Baron and Kenny (1986) stated, the mediation analysis is justified if variations in the independent variable significantly account for variations in the presumed mediator. We conclude that the mediators meet this condition. Regarding the sign of the FTA variable, we obtained a positive effect of FTA on imports of ultra-processed foods and soft drinks, in accordance with expectations. However, the results for the investment variable are less intuitive. Several reasons contribute to explain why the effect on investment is negative. First, it is common to observe an *anticipatory*

[23]The split between unhealthy food and drinks responds to our interest to observe whether factors affect the consumption of both groups of products differently.

effect from private companies when there is a potential trade deal in the pipeline.[24] Second, there might be other confounders affecting investment flows that we did not control for, such as trade disputes between trade partners that can jeopardize a good business environment and other industrial shocks that could make financial managers adopt a more conservative attitude towards investment. Finally, a more favourable regulatory framework for investment also encourages Latin American companies to invest in the US. As the measure of investment is the net investment position in the US, larger investment from Latin American companies pushes down our dependent variable.

The coefficients for the rest of the control variables are in line with expectations. Our results suggest that sugary drinks are imported in countries with a larger share of the population living in urban areas. Higher consumption of soft drinks in urban areas has been reported elsewhere (Ismail et al., 1997). However, we find that junk food imports and investment flows are independent of urbanization rates. In relation to total population, American food companies clearly prefer to focus their investment strategy and export more unhealthy foods and drinks to countries with larger populations. The relationship between per capita income and consumption of unhealthy food is hard to determine, as it tends to be heterogeneous across regions and even within subgroups in a single nation. For example, we know that the largest consumption of unhealthy foods happens in developed countries, but the demand within these countries tends to be concentrated in low-income populations (Block et al., 2004). As Andreyeva et al. (2010) show, food price elasticities are high, with low-income groups particularly sensitive to price changes. We can understand such findings in the current context of low prices in ultra-processed foods and drinks. At the country level, it is however middle-income countries with growing per capita incomes that are experiencing higher demand growth for unhealthy products (Imamura et al., 2015). Most Latin American

[24] Freund and McLaren (1999) investigated this phenomenon for a set of trade agreements. For example, the authors found a three-year anticipatory effect in EU countries joining the Single Market and in the Mercosur members, while investors started to invest even twelve years before in the case of the NAFTA Agreement.

countries belong to this income group, and this helps to explain why we observe a positive relationship between per capita income and import demand for these goods. Countries with higher GDP per capita also capture more investment from American food companies. Imports of other foods and imports of manufacturing goods are separated due to potential substitution effects between food products.[25] Our results suggest no association between junk food imports and imports of healthier food items, but the positive and significant coefficient in column 3 could be a signal that a reshaping of food environments is taking place, with more US investment. The positive effect of manufacturing imports on investment might also indicate that a dynamic business environment across multiple sectors can attract investment from US food companies. Cultural proximity to US is another factor influencing the consumption of junk food. The role of globalization in social integration and the *westernization* process have been previously reported (Oberlander et al., 2017; Pingali, 2007; Costa-Font and Mas, 2016). The results suggest a significant and strong association between close cultural links to the US and imports of unhealthy foods. Finally, education also seems to play a role in food consumption choices. Countries with a low rate of adult educational attainment are likely to import higher quantities of unhealthy food. In contrast, cultural ties and literacy rates do not seem to influence investment flows.

Table B.4 in Appendix B.3 presents the results for variables affecting the costs of obesity without including the mediator. This regression corresponds to path c in Figure 2.1.[26] Again, we separate the results into three regressions, this time corresponding to the three obesity costs estimated under different assumptions about disease coverage and the costs included. In the first and second columns, the dependent variable includes all diseases listed in Appendix B.1, and the difference arises from different assumptions on medication,

[25] We do not refer to other foods as healthy food, due to the different classifications of foods, and the presence of processed foods within this group.

[26] In Appendix B.3 we present the results of the linear regression for path c while controlling for a and b. This is a close representation of the mediation analysis, but it does not provide significance levels for the entire mediation process, Instead, we have significance levels for legs a and b separately.

texting, and service costs on the benchmark diabetes costs taken from Barcelo et al. (2017). Estimates in the second column include higher costs on these expenditures, and therefore imply higher direct costs for the public health system. Obesity costs in Column (3) are based on the same assumptions as column (2), but only includes two diseases: diabetes type 2 mellitus and hypertensive heart disease. The rationale to include these estimates is twofold. First, Fernández et al. (2017) demonstrate that a large share of the costs associated with obesity come from these two diseases. Second, we need to add a step in the calculation of the obesity costs due to the lack of unitary disease cost for each Latin American. This method, based on Rtveladze et al. (2014), might not properly capture the different operational cost efficiencies in the public health system of each country. We only have detailed estimates for diabetes costs. Therefore, expanding the estimation only to one disease –along with diabetes– instead of thirteen helps to minimize potential computational errors.

From the results, we can observe that all coefficients indicate a strong relationship between FTAs and the cost of obesity. Estimates in column (3) present the strongest relationship with FTAs and, therefore, the dependent variable of reference in our mediation analysis only includes the costs of diabetes type 2 and hypertension (*CoO3*). It is worth noting that, despite Baron and Kenny (1986) initially considered that a strong significance in the independent variable of interest is a necessary condition to validate the mediation model, more recent studies contradict this argument (Preacher and Hayes, 2008). The mediation results using costs of obesity estimates from columns (1) and (2) are presented in Appendix B.4 and described in the next section.

Regarding the other covariates, the results are largely aligned across the three regressions. It is important to note that some of these factors might be affecting obesity rates, while others might be drivers of public health expenditure. For example, a variable believed to affect public health costs, independently of the disease, is the population size. Countries with large populations tend to have higher pressure on their health systems, and costs are usually higher as the demand for health services is stronger. Similarly, governments in developed nations allocate a larger budget to the public health system. According to WHO figures, the US has by far the largest per capita healthcare expenditure, combining public and private expenditure. Focusing on government expenditure per capita, the US is still at the top of the list, even though it runs a system that largely depends on private remittances. This is also what we observe in our regression estimates. Urbanization rates serve as a proxy for physical inactivity, which has a direct impact on obesity rates through lower energy consumption. Urban population is associated with sedentary lifestyles and lower rates of physical activity, as found in previous studies (Popkin, 1999). We also incorporate imports of other foods, as they can have an impact on dietary habits. The results show a positive and significant association with obesity costs, suggesting that the imports of other foods also play a role in the rise of obesity rates in Latin American countries. For example, the US is a big exporter of red meat, another product associated with obesity, which is not included in our list of junk food products. Countries like Mexico and Chile are top importers of American red meat. On the contrary, industrial imports seem to have no impact on obesity costs. This suggests that the potential benefits from trade liberalization due to better access to medicine and medical equipment used to treat obesity-related diseases do not have a significant effect. Our estimates also show a negative association between cultural proximity and the costs of obesity. Note that we are also controlling for food imports, so any change in diet induced by cultural links is already absorbed. Finally, the estimates for literacy rates suggest that low levels of education are associated with higher obesity costs. Education is not only a relevant factor in determining eating behaviours, but also in the overall decisions made about having a healthy lifestyle.

Finally, we present the mediation results in tables 2.1, 2.2, and 2.3. We run a hundred simulations for each estimation. Results conducted for a thousand simulations are reported in the next section. The first column shows the regression estimates, along with confidence intervals and p-values in columns 2 to 4. The results show significant indirect effects for the three mediators. The first conclusion that can be drawn is that the mediation effect is partial because the ADE coefficient is still significant in the presence of the mediators. Nonetheless, the indirect effect is sizeable enough to suggest that policymakers should take the nutritional effects of trade into account. ACME estimates for imports of food snacks have the strongest and most significant causal mediation effect. The indirect effects on the costs of obesity from imports of sugar-sweetened beverages are also non-trivial considering the reduced set of items composing this group. We also tested the model by adding in a single variable the imports of unhealthy foods and drinks. These estimates, presented in Table B.7 of Appendix B.4, are similar to those in Table 2.1. The table also shows that the sum of indirect effects coming from junk food and SSBs represents nearly half the total effect that FTAs have on obesity costs.[27] Therefore, trade negotiators should consider additional clauses in trade agreements that could limit the entry of unhealthy food and drinks into domestic markets. This recommendation was also made by Rayner et al. (2006), who underlined how governments lose control over food supply chains as the reliance on food imports increases. To date, the use of sanitary and phytosanitary measures and other food standards has been the only tool utilized to control for the quality of food and, based on our results, they are currently unable to improve the nutritional value of domestic markets.

[27] The "proportion mediated" coefficient indicates the proportion of the total effect of FTAs on obesity costs that can be explained through our mediators. The exact figure in Table B.7 is 45.23%.

Table 2.1: Causal Mediation Analysis - Junk Food Imports

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.2199***	0.1134	0.33	<2e-16
ADE	0.2487***	0.0934	0.40	<2e-16
Total Effect	0.4687***	0.3022	0.63	<2e-16
Prop. Mediated	0.4733***	0.2788	0.73	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table 2.2: Causal Mediation Analysis - SSB Imports

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.1366***	0.0424	0.24	<2e-16
ADE	0.3319*	0.1246	0.50	0.02
Total Effect	0.4684***	0.2523	0.69	<2e-16
Prop. Mediated	0.2910***	0.0832	0.60	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Investment flows coming from US food companies show the weakest indirect effect. However, the direct effect is still strong and significant. An important consideration is that we are only measuring the effect of investment from food manufacturing companies. There is no available sub-industry granular data that could allow us to include the effects of wholesale and retail investment companies, such as convenience stores and supermarkets. The role of the food distribution industry in weight gain has been previously demonstrated (Giuntella et al., 2020; Courtemanche and Carden, 2011). Here, we are only measuring the effects

Table 2.3: Causal Mediation Analysis - US investment

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.04131*	0.00296	0.10	0.04
ADE	0.35286***	0.18582	0.55	<2e-16
Total Effect	0.39417***	0.22140	0.59	<2e-16
Prop. Mediated	0.09206*	0.00745	0.30	0.04
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

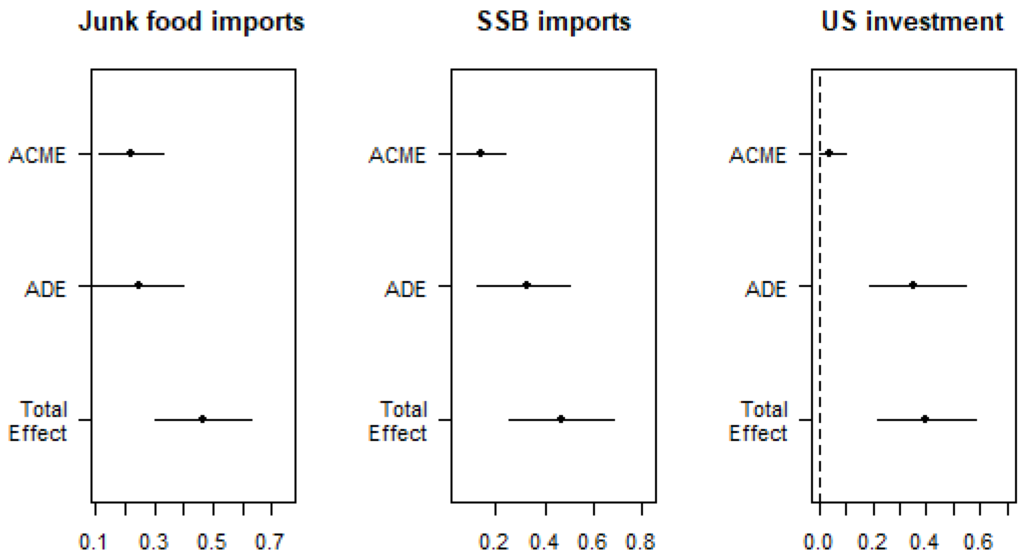
of capital investment in the initial stages of the food supply chain, and this might help to explain why there is still a large proportion of the effect that is not captured.

Figure 2.2 displays a graphical representation of the mediation analysis. Overall, we can conclude that trade liberalization contributes to the rising costs of obesity, and its effect is partially explained by imports of highly caloric foods and drinks. However, there are other underlying factors not yet explained by our model. This is evident in the size of the ADE estimates and opens the door for further research. These factors might not be necessarily related to trade, but other factors affecting obesity costs, such as other supply and demand shocks in food environments induced by FTAs -the above-mentioned effect of the food distribution sector or an increase in the marketing of junk food, among others- and physical inactivity.

2.5 Sensitivity analysis

We conduct a series of robustness tests to add validity to our mediation analysis. The results of these tests are presented in Appendix B.4. Unlike the previous section, we

Figure 2.2: Graphical representation of mediation, direct and total effects.



now combine into one single mediator the imports of snacks and soft drinks. This does not change the expected results, as it is shown in Table B.7, which replicates the results from the previous section. Due to the reduced size of our sample, we opted for setting one hundred simulations as the iteration of reference for the results reported in the previous section. We tested the model running the mediation analysis with a thousand simulations, which is the standard value in the mediation software package, and the pattern of coefficients holds.

Next, we test the model using three-year and five-year lags on the FTA dummy variable instead of one single year. This test is necessary because it is difficult to determine the timeframe that our mechanisms take to interplay with obesity costs. The process from the signature of an FTA to observing changes in the consumption of food and drinks, gaining weight, and developing obesity-related diseases might span several months or years. The three-year lag regression in Table B.10 shows the strongest effect from the set of lags tested. It is the only year in which the explanatory capacity of the mediator overpasses 50% of the total effect. This finding suggests that the FTA effect on obesity costs through imports of junk food reaches a peak in the third year after the FTA signature. As for investment flows, the indirect effect is insignificant, suggesting that most of the effect happens immediately. This might not be surprising, as previous studies have found that a large amount of foreign direct investment inflows into Mexico happened immediately after the signature of the NAFTA agreement in 1994 (Monge-Naranjo, 2002). Estimates after a 5-year period has passed, reported in Tables B.12 and B.13, still show a significant ACME estimate for imports of junk food. The mediation effect through changes in the consumption of junk food and drinks remains as the only driver pushing up healthcare costs, as the direct effect of FTAs is not significant. This is another interesting finding, showing that the influence of FTAs on the import demand of unhealthy foods and obesity is long-standing. We do not observe any significant effect in the regression using investment flows as a mediator.

Finally, we run the model using the other two obesity costs that we calculated in section 2.3 under different assumptions in Tables B.14 to B.17. In these models, the dependent variable is constructed using a more comprehensive set of diseases. However, the results are largely in line with our main estimates. This result provides a hint that the obesity cost estimates constructed with only the two main diseases accurately capture the effects of FTAs on obesity.

2.6 Conclusion

Our study examines the extent to which trade agreements with the US affect public health expenditure through changes in consumption of SSB and snacks. To do so, we first construct a dependent variable based on the estimation of healthcare costs associated with obesity. Most studies assessing the causes of obesity focus on a specific country, normally supported by health and household survey data. We contribute to the literature on obesity economics by generating the first comparable estimates for 18 Latin American countries. Per capita obesity costs are particularly high in Central American countries, which all have trade deals in place with the US.

The linear regression results sketch the role of the different variables in the model on imports of unhealthy food, as well as the mounting obesity-related public health costs. The most important result is that free trade agreements significantly increase snack consumption and obesity costs. Urbanization, education, and cultural globalization are also contributing factors to the rising demand for processed foods and drinks. Other factors affecting obesity costs via changes in physical activity or health expenditure are urbanization, per capita income, and government expenditure. The results of our mediation model put forward one of the main mechanisms through which trade liberalization contributes to the economic burden of obesity, i.e., through promoting imports of foods and snacks. However, part of the effect is not yet explained and further research is needed to gain a more holistic understanding. A possible factor is the establishment of US wholesale and retail food companies that largely sell unhealthy food and drinks in Latin American countries.

Several policy recommendations can be drawn from the study. Regarding FTA negotiations, policymakers might want to incorporate clauses to protect consumers' health by limiting the market dumping of processed food. A potential policy could be similar to that implemented for certain products based on their environmental footprint. If the environmental impact of a product is considered disproportionate based on a set of indicators, an additional price levy on imports kicks in. A similar approach could be applied based on the nutritional value of food and drinks, with additional entry costs for imports of products high in sugar, salt, and saturated fats. Likewise, further standardization of nutritional labels and other consumer information policies at the international level might allow consumers to take more informed choices on food purchases. For example, a "reduced fat" label does not necessarily imply the same product modification in different countries. Finally, it is important to consider the market inefficiencies that trade liberalization can create in relation to these products. Reducing tariffs and other trade costs for imports of snacks and soft drinks (and their inputs) might be counterproductive to food and sugar taxes that the same government might implement to control the consumption of these goods.

The complexity of our model has made evident the multiple limitations encountered in the empirical analysis. The first important aspect to consider is that there are multiple assumptions made in the estimation of obesity costs, and the results can significantly change on this basis. The method used (top-down Vs bottom-up approach), the diseases considered, the types of costs included, and the period of analysis are all determining factors.[28] Lack of comparable data is another important hurdle in the estimation of costs. Further work on the collection of health data by government and institutions might help to significantly improve estimates of the economic burden of obesity. This includes better information on the incidence of obesity and overweight. Although the association between BMI and obesity has been previously demonstrated, the factor most correlated with obesity-related diseases is abdominal fat. BMI is not the most accurate indicator for abdominal fat, but the best proxy we can obtain for a cross-country analysis. Waist circumference and the waist-to-hip ratio better identify individuals at high risk of obesity-related morbidities (WHO, 2011). Regarding the mediation analysis, it was not possible to control for certain factors considered important in obesity trends. Physical inactivity has been proxied through urbanization, but a better indicator is desirable. Genetics is another determinant of obesity for which data were not available. The consumption of snacks and drinks is also influenced by marketing and advertising campaigns, but there is not consolidated data that could be incorporated in the model. Finally, our analysis of the impact of investment is limited to the food manufacturing sector, leaving aside the food distribution subindustry. A cross-country assessment to understand how the establishment of foreign convenience stores and supermarkets affect obesity would bring more light on potential investment policies that could minimize any negative effects on food

[28] For a detailed review of studies published on obesity cost estimation between 2011 and 2016, see Tremmel et al. (2017).

consumption habits and obesity.

Chapter Three

Resilience of agricultural markets during the COVID-19 crisis from a trade policy perspective: a multi-country analysis

Abstract

The ongoing COVID-19 pandemic has led to severe economic consequences worldwide. The global health crisis has affected supply and demand, both domestic and internationally. However, the shock has been noticeably heterogeneous across sectors. Since the onset of the pandemic, agricultural markets have been resilient compared to other industries, in part due to relatively stable international trade flows. Are export restrictions less determinant? Have countries adopted a more trade-promoting approach compared to the previous food price crisis a decade before? This study explores trade policy interventions adopted since the onset of the pandemic, using a gravity setting with data on monthly trade flows. Overall, our findings suggest that government interventions have had a diverse effect on agricultural trade compared to the 2007-2008 crisis. Despite initial and short-lived export restrictions, the government focus has been on trade inflows. The largest effect comes from trade promoting measures and the benefits translated into enhanced trade across all regions. Some of these practices, such as acceptance of digital import documentation, could be established on a permanent basis, while others, like temporary elimination of import quotas, might be considered as efficient interventions for future crises. Products of animal origin suffered the most from import restrictions. The lesson learnt is that timely and accurate information on the potential health risks from these products should be notified internationally (e.g., WTO Committee) as soon as possible to avoid speculation and unnecessary disruptions in these markets. Food import dependent nations are still vulnerable to crises as they are very sensitive to export restrictions, even if very temporary. Therefore, keeping a certain level of stock in key staple foods as well as a diversified portfolio of trade partners is imperative to ensure the resilience of domestic food markets.

3.1 Introduction

On 30 January 2020, the World Health Organization (WHO) declared that the outbreak of viral infections lashing the People's Republic of China during the latter months of 2019 was a Public Health Emergency of International Concern.[1] Less than two months later, on 11 March 2020, the novel coronavirus became officially a pandemic.[2] Since then, efforts around the world have focused on containing the health, economic and social consequences of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic. According to the latest data from the Johns Hopkins University, we exceeded 400 million confirmed cases globally in February 2022, a downward estimate given the limited testing rates. What is worse, the global death toll is near 6 million people. The pandemic also led to disruptions in regular operational activities across all sectors of the economy, particularly in the first months of the outbreak. Global GDP declined by 3.1 percent in 2020, the strongest impact felt in advanced economies during the second quarter of the year (IMF, 2021). Other indicators that provide a diagnosis of the world's economic status –employment rate, real private consumption– also fell dramatically. By sector, services were the most affected due to the direct impact of COVID-19 containment policies. According to UNWTO figures, the annual change in international travel was a decrease of 73 percent. Global merchandise trade also felt the effects of the crisis, with an average 7.6 percent drop compared to 2019, in value terms (WTO, 2021).[3] However, the global agri-food system showed signs of strength, with a 0.9 percent increase in value, while the trade in volume showed a reduction of 2.3 percent.

A common characteristic of the COVID-19 economic recession is the heterogeneous effect across industries and regions. This feature has also been observed in the agricultural

[1] The exact location and source of viral transmission remain unclear, and it is subject to strong controversy.
[2] WHO Director-General's opening remarks at the media briefing on COVID-19.
[3] The annual change in volume for merchandise trade was a negative 5.3 percent in 2020. The difference with the figure in values may underlie a surge in international prices, due to food supply disruptions, and in trade costs, including higher rates on transportation and freight insurance.

sector. Schmidhuber et al. (2020) calculated the exposure of the agricultural supply chain to supply and demand shocks caused by COVID-19. The authors show a diverse impact of the channels of transmission across countries. On the supply side, developed countries intensive in capital showed higher dependence on input markets, which were disrupted shortly after containment measures kicked in. On the demand side, the estimates revealed higher exposure for developing countries, which can have important consequences for food security. The exposure is associated with higher dependence on imports and higher vulnerability of household income flows to adverse events. Aware of the exposure to international markets in the era of globalization, some governments included trade policy interventions in their strategy to minimize the effects of the pandemic. The temporary imposition of non-tariff measures, particularly export restrictions, is a known political resource from previous crises that triggered high volatility and spikes in prices in the past (Martin and Glauber, 2020). These measures tend to have the primary objective of ensuring self-sufficiency. The health crisis encouraged some governments to implement policies to control trade flows, namely, in three product categories: personal protective equipment (PPE), medical supplies and food.

The primary question we empirically address in this paper is whether COVID-19 related trade interventions have contributed to the relative resilience of global agricultural markets.[4] Trade is a double-edged sword to resilience. By definition, international markets can smooth domestic supply issues by resorting to the foreign supply. At the same time, it can be the channel for transmission of policy-induced shocks (FAO, 2021b; Puma et al., 2015). Nowadays, NTMs are studied in detail given their capacity to distort trade. In particular, there is evidence on the use of Sanitary and Phytosanitary measures (SPS) and Technical Barriers to Trade (TBT) to protect domestic markets when tariffs are reduced (Orefice, 2017). Furthermore, SPS measures imposed on agricultural commodities can hinder market

[4]Agri-food systems' resilience is defined as the capacity over time to sustainably ensure availability of and access to sufficient, safe and nutritious food for all, and sustain the livelihoods of agri-food systems' actors in the face of (negative) external shocks (FAO, 2021a). Therefore, we explore whether the availability of imported food has increased or decreased after the implementation of new trade policies.

entry by increasing fixed costs, and thus affecting the extensive margin of trade (Crivelli and Gröschl, 2016). High fixed costs limit the capacity to export for smallholders and small food manufacturing firms, as they tend to operate with tighter markups. Government interventions in periods of crisis include a trade policy strategy to protect national interests. The onset of the pandemic was characterized by the imposition of export restrictions, but they were short-lived (FAO, 2021a). Countries subsequently opted to relax tariffs, quotas and licensing requirements in an effort to enhance trade.[5]

The diversity of trade policy action makes it difficult to predict the overall role of government intervention based on statistical analysis. To the best of our knowledge, this is the first study exploring COVID-19 trade policy measures in an empirical setting. Previous studies have looked at the effects of the pandemic on COVID-19 from a more general policy perspective. For their analyses, authors have relied on health indicators and social policies, such as COVID-19 deaths, cases or mobility restrictions to understand the changes in trade flows (Arita et al., 2022; Masood et al., 2021). Ahn and Steinbach (2021) look at the probability of trade authorities to intervene depending on the health situation, but they do not assess the efficiency of the policies. However, there is still no quantitative assessment of these trade policies. For the empirical strategy, we rely on the gravity model of trade using monthly data as in Grant et al. (2021). Our findings underline the relevance of trade intervention on the importer side. More precisely, import facilitating measures have significantly helped to keep global food markets healthy during the COVID-19 crisis. A strategy to facilitate imports seems thus pivotal to increase the resilience of the global agri-food system. Among the measures stand out tariff reductions and the introduction of schemes for the generation and acceptance of electronic certificates. Our main regression also points to the distortion created by import prohibitions, although these results are not robust

[5]Among the notifications reported by WTO members, two-thirds were technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures with the aim of streamlining certification routines; heightening entry requirements on live animals; and ensuring food security by relaxing technical standards (WTO, 2020).

compared to other model specifications. Export restrictions have had, to a certain extent, negative effects on trade, but the findings are not strong as export bans and prohibitions did not last for long. Export facilitation has played a much smaller role in shaping trade flow.

The contribution of this paper can be described in three areas. First, we construct a database of COVID-19 trade-related measures from multiple sources. This is the most complete trade policy dataset during the period of January 2020 to June 2021. Second, we quantitatively estimate the impact of these measures on international trade flows. Our findings help to define the role of trade policy measures on the resilience of the international food system. We compare with pre-pandemic policies and extend the analysis to specific food groups, geographical regions and net importers Vs exporters of cereals. Finally, we contribute to the literature on non-tariff measures, identifying the responsiveness of global markets to the tailored intervention during the first 18 months of the pandemic. We also extend the analysis of the consequences of COVID-19 from previous studies that only accounted for the first wave of the pandemic (Espitia et al., 2022; Hayakawa and Mukunoki, 2021; Masood et al., 2021)

The remainder of the paper is organized as follows. Section 2 provides an overview of the effects of the pandemic and the existing empirical evidence. Section 3 introduces the model specification and describes the data. Section 4 presents the results and describes the main findings. Section 5 discusses existing econometric issues and provides alternative results for robustness. Section 6 concludes.

3.2 Literature Review

A rapidly growing body of literature in social sciences has focused on the economic impact of the COVID-19 pandemic, either evaluating the economic consequences of containment measures or quantifying the socioeconomic effects of the health crisis (Brodeur et al., 2021). A remarkable common finding is that the policy responses to contain the spread of the virus, from workplace closures to social distancing, created greater economic damage than the macroeconomic impact of the spread of the virus itself (Luckstead et al., 2021; OECD, 2021). The economic projections underline the harm caused by the high level of uncertainty, which arises from the difficulties in predicting the end of the pandemic. On the agri-food sector, the studies during the first months of the pandemic focused on describing what could be observed from the limited available data. In an effort to anticipate potential weaknesses in the food system, Schmidhuber et al. (2020) created an exposure index, based on a set of associated factors for which data were readily available. The authors use unweighted *Manhattan distance* to rapidly identify areas for action.[6] In broad terms, the index reported lower resilience on the supply side for developed economies. The main reasons are the high reliance on input markets, whose supply is more vulnerable to containment measures, and farmers' dependence on access to credit. Developing countries scored a higher exposure than developed countries in the demand side. Higher dependence on food imports and their vulnerability to income loss impair the resilience of their food markets.

The OECD published a study on the challenges arising from the first months of 2020, with the purpose to separate them from pre-existing problems (OECD, 2021). They refer to a "triple-challenge" before the outbreak, consisting of providing affordable and nutritious food to a growing population; ensuring stable incomes for all actors throughout the food supply chain; and making the agri-food sector more sustainable. The well-functioning of the food system was already questioned before the pandemic, and any lessons learnt from the health crisis should still aim to target these areas of concern. The report focuses on the first challenge by exploring potential risks to food availability and consumer's access to food. The authors pay special attention to bottlenecks in the production and distribution systems. A review of the

[6]By *unweighted*, the authors mean that they do not assign more importance to any factor.

dynamics of input markets during the pandemic determines that a scarce labour supply was the most notable setback. The limited mobility caused by lockdowns and travel restrictions posed difficulties in the planting and harvesting season, particularly in labour-intensive sectors like fruits and vegetables. There was also a latent threat caused by seed shortages. It turned out not to be a major problem, as the timing played in favour of markets. Seeds for the 2020 season were already distributed, but concerns arose regarding supply uncertainty for the next growing season based on two factors. First, seeds are also intensive in labour. Second, they are often transported by air routes and the existing international travel restrictions hit the logistical structure. Pesticides were also in the spotlight at the onset of the pandemic as China is a major supplier, but no significant problems were announced beyond the initial weeks of the pandemic. Energy and fertilizer markets showed better resilience to the health crisis, with only isolated cases of local disruptions.

The measures to curb the spread of the virus also hit the operational capacity of the food processing sector. Again, the labour-intensive industries, like meat processing, showed a certain degree of vulnerability due to production adjustments to social distancing rules and labour shortages caused by illness. In the United States, the food manufacturing industry is considered essential and employees kept working in plants during the worst of the pandemic. The difficulties of keeping physical distance led to high rates of infection among workers in meat and poultry processing facilities (Dyal, 2020). By contrast, capital-intensive industries like grain handling and processing coped better with alterations in the production system demanded by government restrictions. Finally, the OECD study points to quarantine measures as a major constraint on transportation and logistics. Problems were most pronounced for perishable high-value products, such as fruits and vegetables. While banana plantations have remained fully operational in Ecuador, supply chain bottlenecks were reported at the ports.[7]

[7] Disease Is Ravaging the $25 Billion Banana Industry. Bloomberg, 22 May 2020. Accessible at https://www.bloomberg.com/news/features/2020-05-22/the-25-billion-banana-industry-is-being-ravaged-by-disease

The crop sector showed higher resilience to logistical difficulties, as bulk transport was less affected. Cereals require minimal labour input for loading, transportation and handling, as many procedures are automatized.

A trade team from FAO conducted a more specific assessment of the effects of the first wave of the COVID-19 pandemic on international agricultural markets, and reviewed the trade measures imposed by governments during this period (FAO, 2021a). Overall, global commodity markets showed remarkable resilience to the health crisis, partly led by the efforts of governments and agricultural stakeholders to keep trade open. This strength can be visually noted in Figure 3.1. Despite that the number of new deaths and cases has been on the rise up to May 2021, global trade in agriculture –in blueprint– has remained steady.[8] International trade only showed a certain stagnation at the beginning of the pandemic, when the strictness of policies to contain the virus peaked.

Similar to the OECD report, the study found that policymakers learnt the lesson from the excessive trade policy protectionism during the global food crisis of 2007-08. This time, government intervention at the onset of the pandemic was limited and short-lived. Most export restrictions were imposed by net-importer countries such as Egypt, Kyrgyzstan, or Kazakhstan. While net-importer countries still have the capacity to distort international markets, particularly if they trigger ripple effects, their interventions have a lower impact than similar measures imposed by key food suppliers. The study concludes that the risks related to the pandemic are caused by demand-side effects. A reduction in income and available employment caused by a global economic recession can translate into shifts in food consumption habits towards cheaper, basic food items. This explains why the demand for staples and high-value foods remained solid. Changes in consumption patterns have also been induced by the enforcement of lockdowns, closure of factories and schools, and cancellation

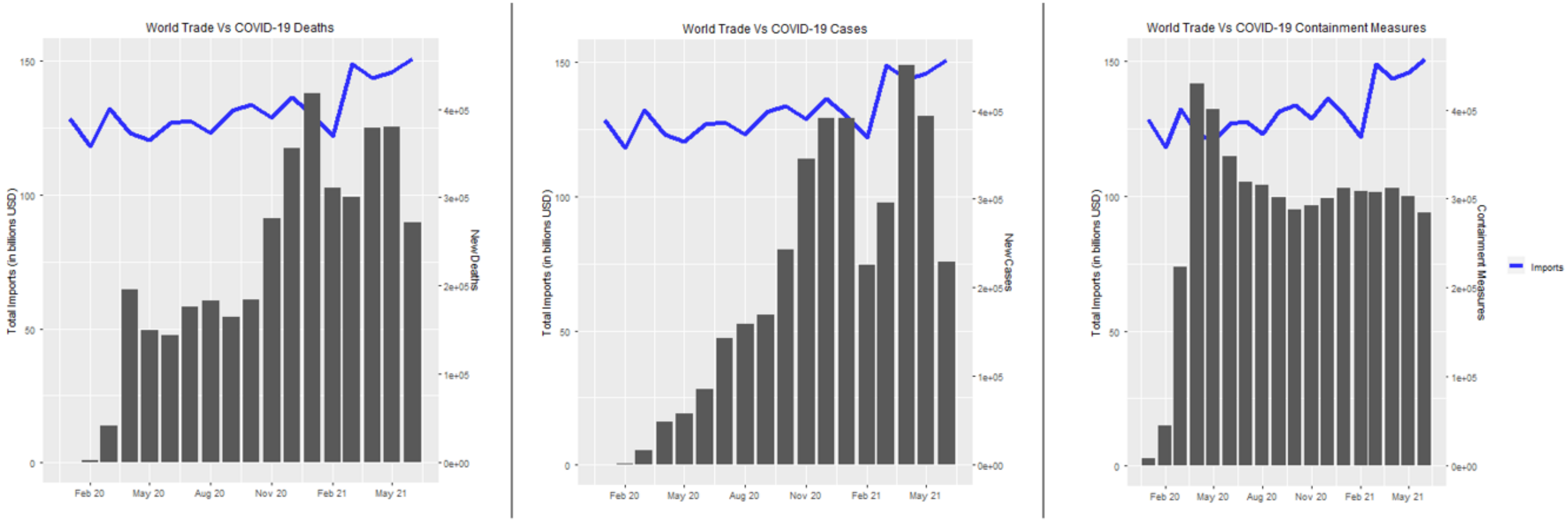
[8] As a note of caution, Figure 3.1 pictures the aggregated trend to have a global perspective. We acknowledge that there is significant heterogeneity both in COVID-19 indicators and trade volumes across countries.

of public events and private celebrations. Products whose demand has shrunk during the pandemic, such as beverages and fish, are frequently consumed away from home. On the opposite side, there was a rise in demand for ready-to-eat foods that can be easily stored. A high share of the demand for non-food products –for example, cotton and flowers–, comes from other industries in the manufacturing and service sectors. Businesses were affected by the containment measures, therefore shrinking the import demand from many developing countries that are key producers of these commodities. The FAO Food Price Index –a Laspeyres price index that is calculated on a monthly basis and indicates the weighted change in prices of a basket of globally traded food commodities– fell in the first months of 2020, reaching the lowest value in May.[9]. According to FAO (2021a), this was mostly motivated by expectations of a downturn in demand.

The FAO study also looked at the relative trade disruptions in specific trade flows. There were no significant differences in trade disruptions when comparing inter-regional and intra-regional trade links. Instead, there was a remarkable increase in trade concentration, both in terms of product range and share of trade flows with key market partners. Concentration happened in those products with higher heterogeneity in product type, quality and origin. The increase in trade concentration reduces the resilience of global agri-food markets as it increases dependence. Similar to the OECD, the study found that trade flows relying on air connections, such as perishable foods travelling long distances, were more affected than products traded through other routes. The impact was in the form of both limited availability and higher cost of air freight. Commercial flights used in the distribution of many fruits and vegetables were severely disrupted in the first months of the pandemic, creating logistical congestion. Although less critical, the adaptation to containment measures was also detrimental for the operating efficiency of harbours, particularly because of quarantine measures as well as additional documentation and examination. In some exporting countries,

[9] FAO provides a detailed mathematical description of the index and its components, available at https://www.fao.org/fileadmin/templates/worldfood/Reports_and_docs/FO-Expanded-SF.pdf

Figure 3.1: Evolution of global agri-food trade during the pandemic (in US dollars) compared to COVID-19 indicators



Sources: Monthly trade data from Trade Data Monitor. Daily new deaths and cases are from Our World in Data and aggregated by month. The first data point is January 22. Daily stringency index is from Oxford COVID-19 Government Response Tracker and averaged by month. The first data point is January 1 governments provided airfreight assistance to farmers and food producers, or launched food procurement programmes to stabilize shocks in demand caused by logistical constrains.

The resilience of the agri-food system has been empirically tested through various methodologies and over diverse shocks. Despite the relative strength showed by the food supply chain compared to other industries during the COVID-19 pandemic, as reported in the FAO and OECD publications, previous models have evidenced that the system is not exempt from flaws. The generalized logistic model proposed by Suweis et al. (2015) finds that the global food system is struggling to cope with the increase in demand from the rapidly growing population. Countries' resilience in the face of demographic growth leans on their self-sufficiency levels, with importing countries showing more difficulties to ensure food security in the long-run. An article by Puma et al. (2015) using the novel methodology of network analysis also advocates for new policies to enhance resilience. The study goes deeper into the complex interrelationships of the global food system by testing to what extent a negative shock propagates through global food networks. They find that, under certain circumstances, a disturbance can propagate globally at a top speed. The best example is the food price crisis in 2007-09. Export restrictions have that potential to rock our complex food system. On the positive side, it has the capacity to mitigate specific interruptions in supply occurring locally in certain countries or regions. The authors also point to a better balance between food self-sufficiency and import dependency across commodities and sectors. Diversification of diets and the variety of commodities and livestock breeds would also reduce the exposure to plant pests and animal diseases.

A growing body of literature is taking a closer look at the NTMs implemented during the COVID-19 pandemic. Ahn and Steinbach (2021) have developed a two-stage model to explore the nexus between the prevalence of COVID-19 cases and the introduction of trade measures.[10] The probability of imposing NTMs on food products to ease trade is lower when the implementing country goes through a wave of COVID-19 cases. Oppositely, countries tend to implement NTMs when the health emergency propagates around the world. Interestingly, the authors also find that the lower the food security level of a country, the higher the probability to impose COVID-19 related trade measures. More recently, Arita et al. (2022) look at the effects of the crisis, breaking them down into four components: prevalence of cases and deaths per million, government policy responses to the pandemic and the Google Mobility indicator. They find that the negative effects have been 2 to 3 times smaller in agricultural trade compared to non-agricultural goods. Overall, the estimated negative effect is around 5 to 10 percent, counting both direct and indirect factors. The authors also point to COVID-19 deaths as the only significant factor reducing agri-food trade. They also find a negative effect in the extensive margin of trade using data on US ports and airports. Masood et al. (2021) obtain the same statistically negative effects of COVID-19 deaths on imports of OECD countries. The authors present a different approach, testing for low and high prevalence at the bilateral level, and interacting bilateral deaths with the exporter's income level. Although the pandemic has adverse effects on trade across the board, imports of fruits and vegetables were remarkably disrupted when the exporter is a high-income country.

Finally, a group of studies has looked at the effects of COVID-19 on total imports and exports as well as comparing across sectors using monthly data. Hayakawa and Mukunoki (2021) find a strong negative effect during the toughest months of the first wave, independently of which of the four indicators they use to measure the health crisis. Nevertheless, the effect diminishes as countries manage to control the spread of the virus. They also find cross-sector heterogeneity. Exporters of labour-intensive good like footwear and transport equipment have been particularly hit, while trade of medical products bloomed as coronavirus expanded. Barbero et al. (2021) interact various COVID-19 variables with a dummy capturing the

[10] The authors use as instruments 12-month lagged GDP per capita, the share of agricultural GDP and employment rate in the agricultural sector.

existence of regional trade agreements. The rationale is that trade integration helps to spread economic shocks across countries. The authors find a larger negative effect in the presence of trade agreements, supporting their initial assumption. The CGE results reported by Beckman and Countryman (2021) suggest that trade had little impact on the agricultural GDP decrease experienced worldwide, but rather a consequence of the shrinking demand in the food services and retail sectors. All these studies, while acknowledging the role of trade policy measures during the pandemic, do not estimate their effects on food trade flows. To the best of our knowledge, this is the first study to disentangle the effects of import and export trade facilitating and restricting measures. Our findings shed some light on how government actions have affected the resilience of international food markets during the new crisis.

3.3 Methodology

3.3.1 Empirical Strategy

Most of the existing literature about the effects of trade measures during COVID-19 is based on descriptive analyses that look at the annual changes in imports and exports. In this section, we present our gravity strategy, which aims at estimating the direct effects of government intervention through tariff changes and NTMs during the first 18 months of the pandemic. One of the main characteristics of our study is the use of monthly data. The monthly dimension adds a new source of variation at the intra-year level, so we cannot rely on the structural gravity specification. A drawback of this setting is the impossibility of accessing to domestic trade data, a variable that has gained importance in gravity research to identify the effects of trade policies within the structural gravity framework (Anderson and Van Wincoop, 2003; Borchert et al., 2021; Heid et al., 2021). Despite this, the gravity model is still a powerful tool in a monthly panel data context. Felbermayr et al. (2021) demonstrate its econometric possibilities by measuring the effects on trade of country-specific natural disasters in a two-step approach. The importer- and exporter-specific gravity parameters are used in a second step to identify short-run supply and demand shocks provoked by earthquakes and storms.

Several authors have published variations of the gravity equation to estimate the effects of COVID-19 health indicators and restrictions. Masood et al. (2021) regress the effects of cumulative deaths per million on total imports, but the lack of product disaggregation does not capture variability within products. Espitia et al. (2022) propose a sector-level model to test the effects of Google mobility data, therefore controlling for sector variability with a specific set of fixed effects. Hayakawa and Mukunoki (2021) introduce a model that only includes bilateral and monthly fixed effects. However, country-specific fixed effects are necessary to control for multilateral resistance (Anderson and Van Wincoop, 2003). We chose to follow the gravity approach proposed by Grant et al. (2021), where the authors estimate the effects of retaliatory measures on US agricultural export flows. Our panel data expands from January 2018 to June 2021. The model to estimate the direct effects of trade measures on agricultural trade flows (X_{ijctm}) in US dollars from country i to country j of commodity c in month m and year t is as follows:[11]

$$X_{ijctm} = exp[\beta_1 \ln \tau_{ijct} + \beta_2 MF_{ijctm} + \beta_3 MR_{ijctm} + \beta_4 XF_{ijctm} + \beta_5 XR_{ijctm} + \beta_6 Z_{ijtm} + \psi_{ictm} + \phi_{jctm} + \mu_{ij} + \epsilon_{ijctm}] \quad (3.1)$$

where the parameters of interest are $\beta_2, ..., \beta_5$. Market restrictive and facilitating measures imposed by the importer j are represented by MR_{ijctm} and MF_{ijctm}. The country

[11]Intuitively, month is defined as $m = 1, 2, ..., 12$, and year $t = 2018, ..., 2021$. Data on year 2021 only cover up to June (m = 6).

of origin i introduces XR_{ijctm} and XF_{ijctm} that aim to limit and ease trade, respectively.[12] For the sake of clarification, import measures are imposed by country i, while export measures are imposed by country j. Therefore, each of the trade partners can intervene and affect their bilateral relationship either by increasing or reducing market barriers. τ_{ijct} is one plus the annual weighted bilateral tariff; Z_{ijtm} is a vector of variant and time-invariant bilateral control variables that determine trade, including information on specific trade agreements and COVID-19 containment measures collected by the Oxford COVID-19 Government Response Tracker (OxCGRT); μ_{ij} refer to bilateral exporter-importer fixed effects; and ϵ_{ijctm} is the error term. Importer (ψ_{ictm}) and exporter (ϕ_{jctm}) fixed effects are controlled at the product c and month (tm) dimensions, and help to control for other unobserved factors –weather conditions, special government financial support– as well as account for trade flow differences in levels.

One modification to the model proposed by Grant et al. (2021) is on the specification of bilateral fixed-effects. The authors use a bilateral-product-month specification ($ijkm$). For the case of retaliatory tariffs, this specification still allows for a proper identification, as retaliation occurs at one specific point. However, this does not apply to our case, as there is a continuous flow of COVID-19 trade policy measures from the onset of the pandemic. Bilateral fixed effects have the benefit of better controlling for time-invariant trade costs than gravity variables (Yotov et al., 2016). We do incorporate the classic gravity covariates (common language, border contiguity, colonial ties and the log of distance) that replace μ_{ij} in the cross-section analysis and a panel setting without bilateral fixed effects for comparison.

We use the standard Poisson-Pseudo-Maximum Likelihood (PPML) regression proposed by Silva and Tenreyro (2006), which allows introducing regressors exponentially as shown in equation 3.1. The PPML regression is robust to heteroscedasticity and, thus, pro-

[12] See Figures C.1 and C.2 in Appendix C.1 for a visual interpretation of how policies have been implemented.

duces consistent estimates.[13] Additionally, the multiplicative estimation with PPML allows for the inclusion of zero trade flows. This point is particularly important in the context of our analysis. Agri-food trade is characterized by a high level of export concentration, as trade depends to a large degree on production factors associated with the countries' characteristics (climate, soil, natural resources). Therefore, our dataset contains many zeroes and, using a log-linear model, we would incur sample selection problems. This is especially the case if the reason for no trade between two countries for a given commodity is correlated with high trade costs (Peterson et al., 2013). Nonetheless, we include the Ordinary Least Squares (OLS) regression in section 3.4 as a robustness exercise.

3.3.2 Data

Our panel database is composed of data from multiple sources. In summary, there are data for 97 importing countries and 176 trade partners, covering 1015 agri-food products at the six-digit level (221 four-digit headings) as per those defined in Annex 1 of the Agreement on Agriculture, World Trade Organization (WTO).[14] The timeframe covers from January 2018 to June 2021, for a total of 42 months.

Trade policies

Unlike other crises, trade policy intervention was not uniquely designed to protect domestic markets. Some governments prioritized food security through easier requirements for imports (import promotion), protect the country from the coronavirus imposing bans on wild animals (import restrictions) or helping local producers to keep a stable income

[13] Silva and Tenreyro (2006) explain that, in the log-linear specification of the gravity model, the error term is not independent of the regressors. In the presence of heteroscedasticity, the log-linear regression leads to biased estimates even incorporating fixed effects.

[14] https://www.wto.org/english/docs_e/legal_e/14-ag_02_e.htm#annI

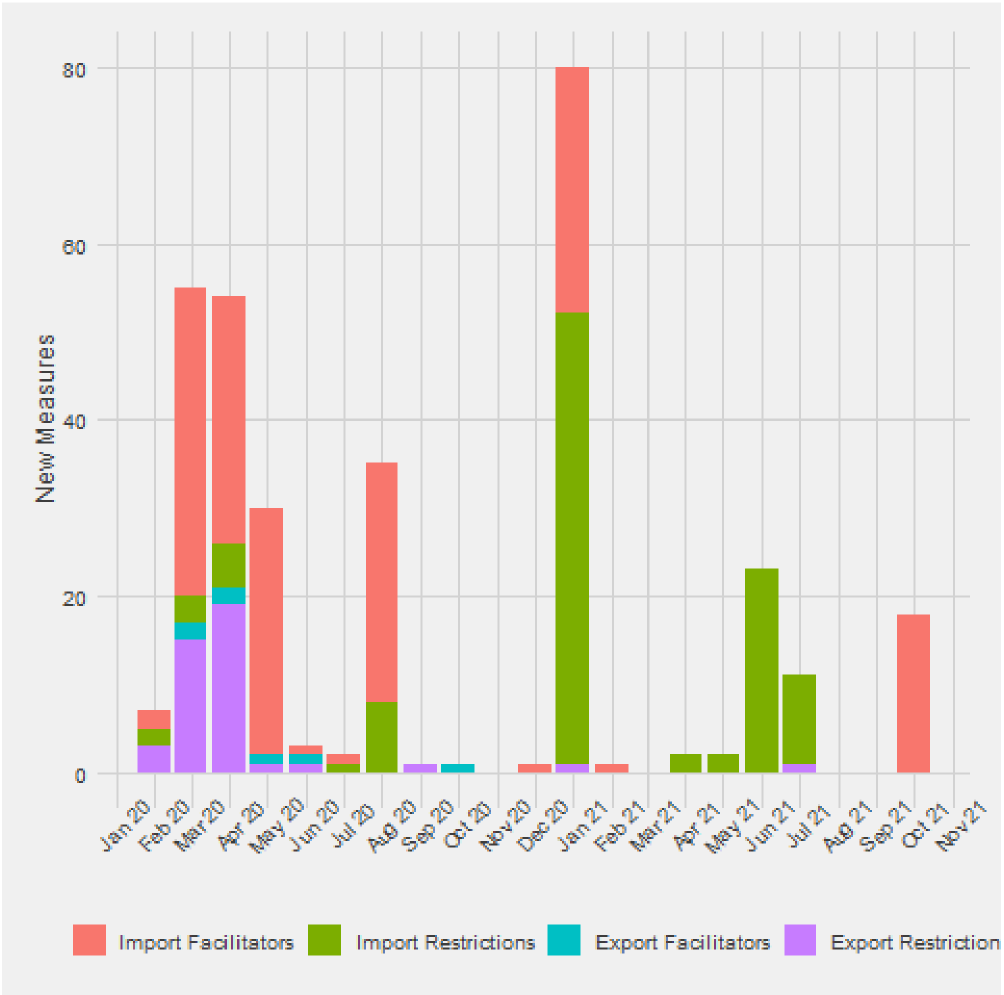
from exports during the health and economic crisis (export facilitation). Therefore, it is important to understand how this mix of trade interventions has interplayed in international agrifood markets. The information on trade policy interventions is not collected in a single database, but rather scattered across several sources. Moreover, the level of detail can vary for the same policy measure reported in various databases. The trade policy dataset we have built is the most important contribution in terms of data from our study. To have the most complete information available based on secondary data, we completed and consolidated the information into one single database.

The baseline for the constructed database is WTO's "COVID-19: Measures affecting trade in goods" database.[15] The WTO compiles here notifications received by member countries about trade and trade-related policies during the pandemic. However, the list of measures is not exhaustive and, sometimes, the information is not accurate enough (e.g., information on the affected products) or outdated. For this reason, we subsequently complete the information and missing trade measures with records from the Market Access Map COVID-19 database of the International Trade Centre (ITC) and FAO's Food And Agriculture Policy Decision Analysis Tool (FAPDA).[16] In the case of export restrictions, we also cross-checked the information with David Laborde's Export Restriction Tracker in cases where discrepancies across datasets arose (Laborde et al., 2020).[17] The dichotomous classification between the liberalizing and restrictive nature of policies is obtained from the "Effect on Trade" variable in ITC-MacMap.[18] For policies without an end date, we assume that the policy endures at least until the end of our period of analysis. Figure 3.2 provides a timeline of new trade interventions since the onset of the pandemic. The first trade policy in the data is an import ban by Georgia's border authority on live animals from China, effective

[15] https://www.wto.org/english/tratop_e/COVID19_e/trade_related_goods_measure_e.htm
[16] http://fapda.apps.fao.org/fapda/#main.html
[17] https://public.tableau.com/views/ExportRestrictionsTracker/FoodExportRestrictionsTracker?:language=en-US&:display_count=n&:origin=viz_share_link
[18] https://www.macmap.org/COVID19

on 28 January 2020. The number of new measures rapidly grows until March-April of the same year, particularly export restrictions and import facilitating measures. Note that the sudden raise in trade intervention in August and January roughly matches the second and third waves of COVID-19. At first sight, it is evident the governments' preference for import facilitating measures.

Figure 3.2: Timeline of trade measures imposed during the COVID-19 pandemic.



Sources: WTO, FAO, ITC and the Global Trade Alert. Chart is author's own elaboration

We then merge the above database with trade policies obtained from the Global Trade Alert (GTA), making sure there are no overlaps. The GTA collects information on policy interventions on medical supplies, PPE and food from the start of the pandemic.[19] Despite being the most ready-to-use data that we found, there are some tweaks needed to have a balanced panel data. For example, we use the announcement date to replace the set of observations for which the inception date is missing. We also drop measures marked as “amber" measures, as it is unclear how they can be assigned to our dichotomous groups of trade restrictive and trade facilitating policies.[20] Finally, we also drop 58 measures for which there is no clear indication of the products affected by the policy. A detailed analysis of the trade policy measures recorded in the GTA database in 2020 reveals a high level of heterogeneity regarding trade policy intervention (Evenett et al., 2021). The heterogeneous application of trade measures is visible in Figure 3.3. The measures are grouped by chapters of the Harmonized System of tariffs. We note a disproportionate number of measures applied to the fish sector (chapter 03), but also to vegetables (07), fruits (08) and meat (02). These products constitute the basic diet in most parts of the world. It is notable that governments did not pay so much attention to cereals compared to these products. The explanation could be found in the possibility of stockpiling cereals and having buffer reserves, while the previously mentioned food groups are mostly fresh products.

Monthly trade data and covariates

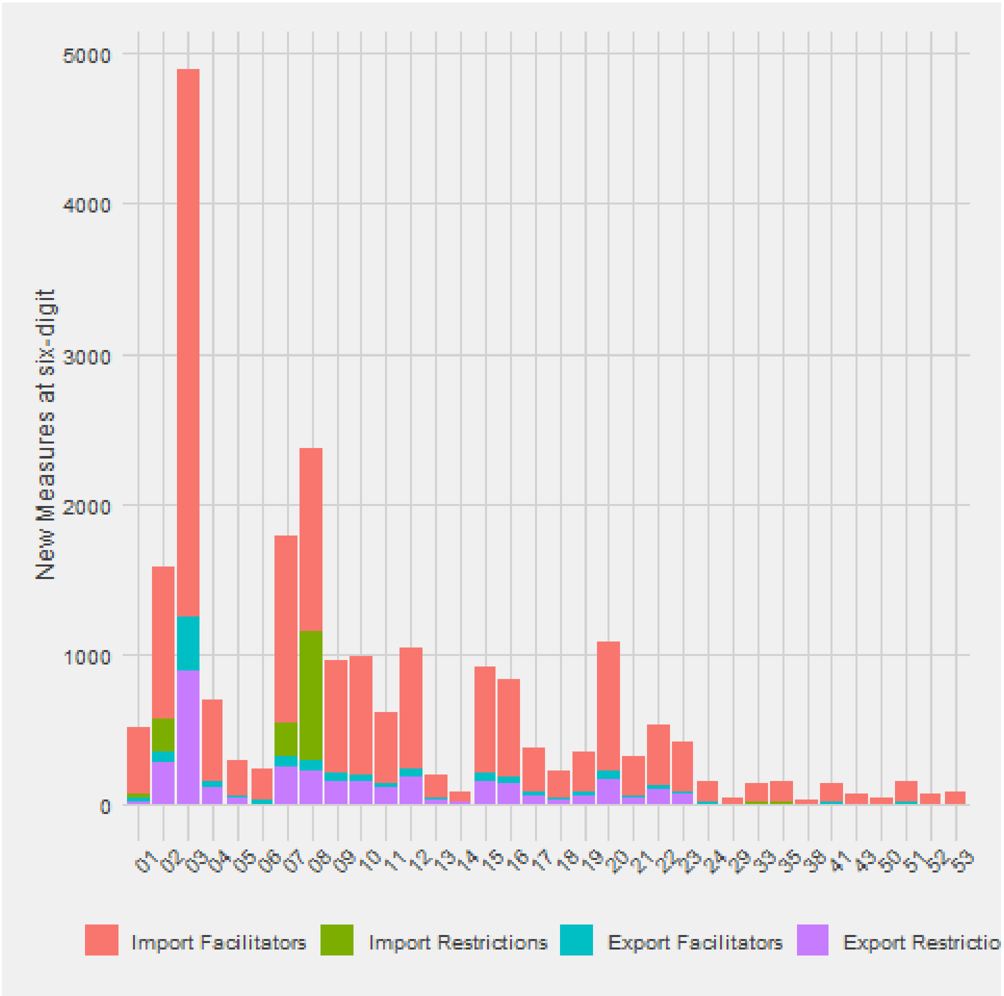
Monthly trade data come from Trade Data Monitor.[21] We use data on imports because data collected by the customs authorities are more precise and provide better information

[19]The GTA dataset on COVID-19 policies is a joint effort by the GTA team, the European University Institute and the World Bank. Evenett et al. (2021) provide a detailed description of the data, while the methodological note is accessible at https://globalgovernanceprogramme.eui.eu/wp-content/uploads/2020/05/Methodologynote050420.pdf.

[20]The amber group represents less than 5% of total measures.

[21]https://tradedatamonitor.com/

Figure 3.3: Trade measures imposed at the six-digit level during the COVID-19 pandemic, grouped by HS chapter.



Sources: WTO, FAO, ITC and the Global Trade Alert. Chart is author's own elaboration

on the final destination of agricultural products. [22] Tariff data are sourced from World Bank's WITS database. We select for our analysis the effectively applied tariffs, which are the lowest available tariffs. The priority is thus given to preferential tariffs. Otherwise, the MFN applied tariff will be used. Tariffs are weighted using the country reference group methodology as in Guimbard et al. (2012). A detailed explanation on the calculation of the weights is available in Appendix C.1. Data on the standard gravity variables are readily available on

[22]Trade Data Monitor (TDM) underlines that data on exports are collected differently, where the trade partner is defined as the country of destination of a product, regardless of the ultimate destination of the good. As a result of this, import and export TDM data does never match. Other frequently used datasets like UNCTAD COMTRADE also reports mismatch on imports and exports.

CEPII's gravity database (Head and Mayer, 2014). The bilateral distance variable is the distance between the most populated city in each country, weighted by population. The contiguity variable is a dummy variable equal to 1 if countries share a common border. The language variable is equal to one if two countries share a common official language. CEPII has generated several variables regarding colonial links. We use the variable that is equal to 1 if both countries have ever had colonial links throughout history. CEPII's information on regional trade agreements comes from WTO's "Regional Trade Agreements Information System (RTA-IS)" and registers the presence of special bilateral trade relationships over time. Finally, we account for the impact of other socio-economic policies implemented in response to the pandemic. The Oxford COVID-19 Government Response Tracker collects data on 23 policy-response indicators and 180 countries (Hale et al., 2021). In our sensitivity section, we show the results including the stringency index to control for the potential impact of lockdowns and other containment measures on the supply and demand of agri-food products.

3.4 Results

Our main results are presented in Table 3.1. Our PPML gravity regressions in columns (1) to (5) are obtained with the *ppmlhdfe* command developed by Correia et al. (2020), which provides a reliable and fast computing solution when using multiple high-dimensional fixed effects. Additionally, *ppmlhdfe* deals with singletons by default. As Correia (2015) demonstrates, keeping singletons when the fixed effects are nested within clusters can lead to overstate statistical significance.[23] Column (6) presents the results of the OLS estimator. The first column is a regression using cross-sectional data from March 2020, when the number of trade measures to contain the pandemic grew exponentially. The cross-section analysis gives a taste of where the source of variability can be by disentangling the cross-section and

[23] There is an underestimation of standard errors.

time dimensions. The estimates are in line with the results of the panel data regressions, presented in the following columns, and suggest that the effects of trade measures applied to products by each country are statistically significant. Columns (2) and (3) differ from (4) and (5) in the presence of bilateral fixed effects. Note that we show the results both at the six and four-digit level of product disaggregation. This is because there is only a small share of interventions tackling specific products, and the four-digit level better reflects the level at which products have been targeted. A four-digit regression also helps to minimize potential bias from zero trade flows, as each group contains a larger group of products. Standard errors are clustered at the country-pair level. The rationale behind is that there is a high chance of correlation between emergency NTMs and the residual. Therefore, clustering at this level matters (Abadie et al., 2017). Trade policy measures tend to affect more country-pairs with high trade flows, as there are trade relations already established. This setting absorbs any within-cluster correlation pattern not already captured by the set of fixed effects.

Figures C.1 and C.2 in Appendix C.1 show the distribution of government intervention at a glance. Import intervention accounts for 65 percent of the total. They are predominantly implemented in the form of tariff reductions, but around 22 percent of the measures to enhance trade are targeting more flexible licensing and certification. That being said, export restrictions are the second most common type of measure, accounting for 33 percent.

At first glance, the coefficients are in line with our descriptive analysis. Measures imposed on imports have the most substantial influence on international markets. Policies facilitating inflows have the largest, most significant effect. The results are strong and significant across all regressions, reflecting the importance of these policy interventions in keeping trade free-flowing. As per column (4), which controls for other bilateral factors, the introduction of a liberalizing import policy can increase imports up to 60 percent during the COVID-19 crisis. The combination of a better import environment and the increase in demand for stockpiling, both staple foods by public authorities and ready-to-eat meals

Table 3.1: Effect of trade policy measures during the COVID-19 pandemic.

	(1) Cross-section (t=2020-03)	(2) Panel hs6	(3) Panel hs4	(4) Pair hs6	(5) Pair hs4	(6) OLS
log tariffs	-0.1714***	-0.1694***	-0.1052***	-0.1084***	-0.0225	-0.0750***
	(0.0308)	(0.0222)	(0.0276)	(0.0161)	(0.0180)	(0.0092)
Import facilitators	0.8586***	0.8146***	0.9660***	0.6069***	0.8006***	1.5989***
	(0.1155)	(0.0953)	(0.1666)	(0.0633)	(0.0896)	(0.0588)
Import restrictions	-0.4283***	-0.1961***	-0.5206***	-0.0837**	-0.2342***	0.2017***
	(0.1010)	(0.0739)	(0.1276)	(0.0421)	(0.0736)	(0.0714)
Export restrictions	-0.3072**	-0.6180***	-0.0146	-0.2181***	0.0520	-0.1418
	(0.1374)	(0.1286)	(0.1380)	(0.0766)	(0.1097)	(0.1028)
Export facilitators	-0.0128	-0.0271	0.1760	-0.2480***	0.0069	0.1379
	(0.3000)	(0.1258)	(0.1905)	(0.0763)	(0.1154)	(0.1551)
log distance	-0.6554***	-0.6296***	-0.6623***			
	(0.0416)	(0.0370)	(0.0463)			
contiguity	0.7102***	0.7463***	0.8168***			
	(0.0891)	(0.0811)	(0.0834)			
common official language	0.4310***	0.3672***	0.2671***			
	(0.0776)	(0.0633)	(0.0682)			
colonial links ever	0.1690**	0.1861***	0.2840***			
	(0.0821)	(0.0692)	(0.0927)			
imp-exp RTA in place	0.1830***	0.2289***	0.3357***			
	(0.0661)	(0.0557)	(0.0552)			
Country-Pair FEs	no	no	no	yes	yes	yes
R-squared						0.6891
Pseudo R-squared	0.9098	0.9128	0.9323	0.9365	0.9596	
Number of observations	128,999	5,132,894	1,192,483	5,277,698	1,229,964	5,277,977

Note: Gravity estimation using trade monthly data. Columns (1) to (5) are reported using a PPML estimator, and column (6) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the 6 and 4-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

by private households, might explain such a strong effect (FAO, 2021a). Although of lower magnitude, the impact of import restrictions is also statistically significant and independently of the level of product disaggregation. This can be explained by the strictness of the policy interventions, as nearly two-thirds of the interventions refer to import bans. Measures to limit exports are also very stringent, with mostly export prohibitions. This is evidenced in the negative and significant effect on trade flows. The lack of significance at the four-digit level can arise from the specificity of these interventions. Export restrictions tend to target a few key commodities that governments consider strategic for self-sufficiency. The negative impact on trade stemming from export facilitating measures is the most surprising finding in our regression. However, the number of measures of this kind is small, and sample sizing could be affecting the results. They refer to reductions in export taxes and licensing fees. The results for the control variables provide robustness to our findings, as they are with the expected sign and significance.

Previous studies have reported high heterogeneity across commodity groups on the number of new trade policies imposed, and the impact provoked by a high prevalence of COVID-19 cases (Arita et al., 2022; Evenett et al., 2021). We ran the gravity model aggregating the data by food groups. The results, presented in Table 3.2, evidence that trade measures imposed from the beginning of 2020 have had, indeed, a heterogeneous effect on trade across the groups. For the sake of space, we only present the full model, including country-pair fixed effects. Therefore, estimates for the gravity covariates are absorbed and not presented in the table.

Table 3.2: Effect of trade policy measures by food group.

	(1) Live Animals & Plants	(2) Meat & Dairy	(3) Cereals	(4) Fruits	(5) Vegetables
log tariffs	-0.0311	0.0309	-0.0773**	-0.0858***	-0.1064***
	(0.0510)	(0.0427)	(0.0317)	(0.0312)	(0.0333)
import facilitators	1.1678***	0.1898	0.4957***	0.5288***	0.6997***
	(0.2062)	(0.1333)	(0.0811)	(0.0591)	(0.0805)
import restrictions	0.2554	-0.3660***	0.0007	0.0031	0.1621*
	(0.1697)	(0.1218)	(0.0824)	(0.0818)	(0.0943)
export restrictions	1.1158*	-0.0377	-0.2933	-0.4641***	0.0370
	(0.6285)	(0.1466)	(0.2025)	(0.1483)	(0.1240)
export facilitators	0.0000	-0.3815	-0.5741***	-0.7333***	0.3486*
	(.)	(0.2483)	(0.1860)	(0.2683)	(0.2028)
Country-Pair FEs	yes	yes	yes	yes	yes
Pseudo R-squared	0.9646	0.9561	0.9518	0.9524	0.9562
Number of observations	176,539	342,070	760,274	769,709	612,609

Note: Gravity estimation using trade monthly data.Columns reported using a PPML estimator and country-pair fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the 6-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Measures addressed to favour imports have had the most significant effect across groups. Live animals and plants have shown the strongest effect, noting the importance of import facilitating measures in ensuring a smooth production in the livestock and horticulture industries. The import of herds and plants is characterized by the compliance with SPS measures. In some cases, they have been accepted electronically to ease trade, reflecting the great importance of advancing in the digitalization of agri-food trade. Cereals, fruits and vegetables have also reacted positively to this type of measures. This demonstrates that trade facilitation can significantly contribute to ensure access to sufficient and nutritious foods even in periods of crisis. Our findings also suggest that meat and dairy are the most negatively altered markets by import restrictions. This is in line with the analysis on the effects of the pandemic by Arita et al. (2022), that finds that these markets were particularly hit during the first waves of COVID-19 infections. We can conclude that trade intervention during the pandemic played an important role in the market distortions. Looking at pre-pandemic evidence, Disdier and Van Tongeren (2010) report that meat and dairy have a high number of NTMs, as well as a high number of concerns submitted by WTO members. Similarly, estimates of ad-valorem equivalents also identify products of animal origin and vegetables as the most restricted sectors through the use of NTMs in international markets (Cadot and Gourdon, 2016). Hence, these are markets that tend to be constrained by intervention. This alignment raises questions to what extent restrictive policy measures are properly justified by the pandemic.

On the export side, bans and prohibitions have hit particularly hard the fruit industry. The effect is concentrated in three interventions: a minimum price on dried grapes set by Argentina and export restrictions on lemons imposed by Turkey and Iran. We cannot reject the possibility that bilateral time-variant effects not captured in the model could be hampering the commerce of fruits, as described by Masood et al. (2021). More remarkable is the negative but no significant coefficient in the cereals group. Products like wheat, maize and rice were specifically targeted at the beginning of the crisis. However, the restriction in most cases lasted days or weeks, and this might explain why we do not observe a substantial trade distortion. Again, the results derived from export facilitation come as a surprise. Trade in cereals and fruits has decreased after the implementation of liberalizing measures by the exporting country, and only trade in vegetables has benefited from them.[24] It is important to mention, that some export facilitating measures are, in fact, lower rates over existing export taxes, so in practice there is an export restriction imposed, even if relaxed. These findings partly contrast with the work of Ahn and Steinbach (2021), which finds no heterogeneity in the implementation of NTMs. We can conclude, however, that NTMs do not affect commodities in the same way, and even sector-wide changes in regulation can have different effects across food groups (Santeramo and Lamonaca, 2019). Governments should take this into consideration when assessing the purpose of interventions.

Table 3.3: Effect of trade policy measures by geographical region.

	(1) North America	(2) Latin America & Caribbean	(3) Europe & Central Asia	(4) South Asia	(5) East Asia & Pacific	(6) Middle East & North Africa	(7) Sub-Saharan Africa
log tariffs	0.0759	-0.0704**	-0.1793***	-0.4147***	-0.1015***	-0.0825***	-0.1194***
	(0.0468)	(0.0317)	(0.0299)	(0.0941)	(0.0303)	(0.0278)	(0.0305)
import facilitators	0.1359	0.0574	0.3544***	0.2298*	0.5097***	0.9825***	0.7061***
	(0.0954)	(0.0872)	(0.0642)	(0.1257)	(0.1514)	(0.1282)	(0.1118)
import restrictions	-0.2054*	0.0874	0.4288***	-0.2156**	-0.4767***	0.2402	0.2532
	(0.1244)	(0.1251)	(0.0607)	(0.1003)	(0.0908)	(0.1903)	(0.1863)
export restrictions	0.1912	-0.5881***	0.2446**	0.9226***	-0.2625**	0.3132	-0.4376***
	(0.1842)	(0.1465)	(0.1085)	(0.2487)	(0.1295)	(0.2457)	(0.1270)
export facilitators	1.7063	-0.3958**	-0.1818	1.2727***	-0.1346	0.3573	-0.0789
	(1.1528)	(0.1859)	(0.1910)	(0.2899)	(0.2168)	(0.2405)	(0.2382)
Country-Pair FEs	yes	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9908	0.9490	0.9407	0.9850	0.9594	0.9561	0.9529
Nr. observations	341,271	638,716	1,707,232	54,114	1,097,737	248,096	280,786

Note: Gravity estimation using trade monthly data. Columns reported using a PPML estimator and country-pair fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the 6-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

We now investigate potential geographical imbalances created by COVID-19 related trade policies. In Table 3.3, we present the results of the model grouping the reporters –that

[24] There is no effect on live animals and plant group because we did not find any record on export facilitating measures affecting this group during the months of study.

is, importing countries– by geographical region. The seven regions displayed in 3.3 are the ones defined by the World Development indicators.[25] The overall assessment is similar to Arita et al. (2022) in that there is not a clearly different effect across regions.[26] The most positive note comes again from import facilitating measures. Except for North and South America, all regions have benefited from this type of intervention. Developing regions show the largest gains. However, they have been more affected by export restrictions. The effect of export restrictions in Latin America, an important region in supplying food to the rest of the world, is particularly relevant. Hypothetical protracted export bans in Latin America could have important consequences for global food security. Import restrictions have a significant negative impact on North America and Asia. The effect of import restrictions in Europe is surprisingly positive. These interventions include a new EU package of import duties and import quotas on certain cereals, fruits and vegetables. Most European countries are mostly net importers of these commodities, and therefore they have a rather inelastic import demand. The import needs that a health crisis creates seem to overcome the negative effect of import restrictions.

Finally, we compare the effects of trade policies across the different market players in Table 3.4. We classify the reporting countries into three groups depending on their status in international cereal markets. We use the Import dependency ratio (IDR) to assign countries to each group.[27] The mathematical definition of IDR is as follows:

$$IDR = (Imports - Exports)/(Production + Imports - Exports)$$

where the complement of the ratio to 100 represents the part of the domestic food supply that

[25] https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html

[26] Arita et al. (2022) classifies the countries by income group and find mixed evidence on the effects of COVID-19 cases on agricultural trade.

[27] We conducted the analysis for cereals as FAO provides readily available IDR figures for this food group.

Table 3.4: Effect of trade policy measures by cereal import dependency.

	(1)	(2)	(3)	(4)	(5)	(6)
	Net exporters		Countries IDR 0-50		Net importers	
	Panel	Country-pair	Panel	Country-pair	Panel	Country-pair
log tariffs	-0.1287**	-0.0253	0.0209	-0.1703***	0.0026	-0.0328
	(0.0651)	(0.0826)	(0.0552)	(0.0363)	(0.0354)	(0.0243)
import facilitators	1.5929***	0.9304***	0.9448***	0.3504***	0.0745	0.1064
	(0.1505)	(0.1155)	(0.1316)	(0.0875)	(0.2460)	(0.1480)
import restrictions	0.2615	0.0132	-0.1607	0.0520	-0.3926	0.0237
	(0.1946)	(0.1470)	(0.1458)	(0.1127)	(0.3036)	(0.2147)
export restrictions	0.8057***	0.6698***	-0.4904	-0.4694	-2.1228***	-0.7103***
	(0.2861)	(0.1620)	(0.5398)	(0.3321)	(0.6838)	(0.2633)
export facilitators	0.2550	-0.3027	-0.5048	-0.3551	-0.1728	-0.4671
	(0.4851)	(0.3094)	(0.4815)	(0.2748)	(0.5608)	(0.3443)
log distance	-0.9729***		-0.8937***		-1.3579***	
	(0.1091)		(0.1127)		(0.1090)	
contiguity	1.4124***		0.4523*		-1.3068***	
	(0.1994)		(0.2531)		(0.2856)	
common official language	0.5476***		-0.2609		-0.5256***	
	(0.1510)		(0.1673)		(0.2030)	
colonial links ever	0.2186		0.3564		0.4446**	
	(0.2000)		(0.3011)		(0.2215)	
imp-exp RTA in place	0.1522		0.5640***		0.1563	
	(0.1626)		(0.1403)		(0.1895)	
Country-Pair FEs	no	yes	no	yes	no	yes
Pseudo R-squared	0.9578	0.9752	0.9230	0.9683	0.9108	0.9590
Number of observations	210,023	223,366	244,941	247,830	218,008	219,023

Note: Gravity estimation using trade monthly data. Columns reported using a PPML estimator and country-pair fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the 6-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

is produced in the country itself.[28] Columns (1) and (2) present the results only for the subset of countries that have a positive trade balance in absolute terms. Note that, however, these countries might be net importers for some types of cereals. Columns (3) to (6) refer to net imports, where the latter two columns refer to those countries with a high import dependency to satisfy their local demand. The results are worrisome, as the import facilitating measures show positive effects in those regions for which imports are less critical to ensure access to

[28]As a caution note, these ratios assume that imports are used for domestic utilization and are therefore not re-exported.

food. Moreover, export restrictions decreased trade in these regions, hitting the farmers' revenue from exports. We can conclude that trade intervention during the pandemic has a heterogeneous effect across countries, with net importers showing a more sensitive trade reaction to trade distorting measures.

3.5 Sensitivity analysis

The estimates in the previous section yield from a model specification without lagged variables, therefore, expecting an immediate effect on trade. We assume such a scenario as the measures imposed during the COVID-19 crisis had the clear intention to generate an effect in agrifood markets in the short term. However, we incorporate regressions with slight lags of one and three months for robustness. The results are reported in Appendix C.3 Longer lags are not considered, as some measured did not last longer than two months, particularly export restrictions. Tables C.1 and C.2 show that the effect of trade measures remains stable over time. Not surprisingly, the effect of export restrictions vanishes in Table C.2, as most measures of this type did not last more than three months.

By food group, we still observe the effect of COVID-19 trade policies, in general. Months after the implementation of import restrictions, a positive effect on trade appears in live products and a negative one in cereals. These effects were not captured in Table 3.2. As for export restrictions, a strong negative effect in cereals trade is the most notable finding compared to the baseline regression, while the positive effect on the trade of live animals and plants decreases over time.

The lagged regressions by import status also support the main findings, while some other important considerations can be extracted from Table C.5. The effects of the interventions on net exporters are unchanged after three months, in broad terms. Import restrictions take longer to penetrate in countries with low dependence on imports, but the reduction in trade flows starts to show up after the first month and gradually increases over time. Import flows in net-importing countries improve due to trade facilitating measures only after the third month, while the negative impact caused by export restrictions gets worse over time.

Agri-food trade is characterized by a high level of concentration. To a certain extent, such level of geographical concentration can be explained by the different allocation of natural resources across countries, as agricultural production is heavily dependent on land availability, climate and soil (Henderson et al., 2018). In other words, it is reasonable to expect no exports of tropical fruits from Nordic countries, even if some local production might exist thanks to greenhouse facilities. Therefore, bilateral data tend to report zero trade flows with high frequency. The presence of zero trade values is particularly pervasive when we use more granular data. Some studies use food groups to help to reduce bias. Finally, the production of many agricultural commodities is seasonal, with a peak in exports –and even domestic consumption– during the post-harvesting season. As we use monthly data in our study, seasonality might be a major bias in our results.

Based on these factors, we run two additional regressions to support our results. First, we replicate the model specification of Grant et al. (2021) and Arita et al. (2022). Our main regression is set with a different specification because of the hypothesis that there is a different pattern for variability in our study. In Grant et al. (2021), the authors look at retaliatory measures, that are characterized by lower frequency and a stronger bilateral component. Trade policies, instead, tend to be more homogeneous, in the sense that they affect all partners at the same time. In Arita et al. (2022), the authors explore the effect of COVID-19 cases. The prevalence of infections is a variable expected to influence agri-food trade in the same manner across commodities. In Table C.6 of Appendix C.2, we present the model using the different fixed effect framework. The results are robust for the import facilitating measures, remaining positive and significant for all the different regressions except for the OLS estimation. However, we find mixed results for other types of interventions. In columns (4) and (5), the ones including bilateral fixed effects, the results are different to our main findings. The outcome of the regression at the 4-digit level aligns better with our results. At the aggregated level, import restrictions still reflect their negative impact on trade flows, while export facilitating policies remain non-significant. The negative effect of export restrictions is now observed at the four-digit level, while results at six-digit are ambiguous. Note that we have also introduced in the model the stringency index, as in Arita et al. (2022). This index allows for the comparison across countries of COVID-19 containment measures, from lockdowns to workplace and school closures. The authors report non-significant effects of stringency measures on agricultural trade at the six-digit product level. This is also what we observe in our estimation.

Finally, we present the results after aggregating the data by quarters in Table 1.2. Again we find consistent estimates on the import facilitating, and they show more clearly their enhancing effect on trade. The outcome of imposing other trade policies is again ambiguous, and their effects vanish as soon as we control for bilateral fixed effects. We acknowledge that there are other downside factors to consider when using quarterly data. Time-interval data has been traditionally used in gravity models to estimate the direct effects of trade policies. The reason behind is that the intervals help to control for short-term fluctuations and absorb the adjustment process to a new policy scenario. However, Egger et al. (2020) challenge this view and state that intervals may inaccurately estimate the policy response. The authors provide three arguments. First, the pre- and post-policy intervals can average out the real policy response. Second, the difference in the time distance of a new trade measure to the previous and next interval will differ across the whole set of measures in the study, leading to potentially biased estimates. Finally, the very nature of intervals, where information is lost along the way, can lead to a less accurate calculation of parameters. This last point is theoretically supported by the econometric importance of the sample size. Hence, there is not an optimal solution to the potential bias generated by the different specifications, but we are confident that the robustness of the results across models support our findings.

3.6 Conclusion

This paper explores the effects of trade interventions during the COVID-19 pandemic. We differentiate between export and import facilitating and restrictive measures. The analysis builds on the gravity model of trade, including the four variables of interest and accounting for bilateral trade relationships. Our main finding highlights the strong effect of measures imposed on imports compared to those on exports. In particular, import facilitating measures stand out in their capacity to keep a smooth flow of agri-food trade, and thus make international markets more resilient. The impact of export restrictions in the COVID-19 crisis has played a secondary role, mostly because of the brevity of their implementation period. The influence of import restrictions and export facilitating measures on global trade has been insignificant or ambiguous. As the regression of food groups exhibits, the import elasticity of certain goods is proved to be highly inelastic, and import bans and restrictions might just take importers to divert demand to other partners or substitute goods. Only a few measures of export facilitation have been recorded during the pandemic, and their capacity to influence trade is limited. In the absence of restrictions, exports have been likely dependent on stronger domestic demand. However, we cannot confirm this fact due to the lack of monthly intra-trade data. Future studies should endeavour to incorporate domestic demand into the regression analysis, given its manifest importance (Heid et al., 2021). Similarly, we acknowledge the relevance of disruptions in the shipping industry during the COVID-19 pandemic. The impact of transportation is partially captured by importer and exporter fixed effects -because disruption largely occurred globally, across all shipping and air routes- and, in addition, agriculture and food manufacturing sectors exhibit higher resilience to shocks in global value chains.[29] However, further research might want to incorporate transport data into the model as a matter of robustness.

Our findings are limited to the role of public policies on strengthening the global food system. The lack of available data is a major challenge, and the existing evidence is limited to case studies (Beghin et al., 2015). However, we acknowledge the important role of private action on markets, from farm unions to food and trading companies. Disentangling simultaneous public-private interventions in markets is a major challenge to better understand the dynamics of food systems. For example, Indian rice traders stopped signing export contracts as soon as the government imposed nationwide lockdowns.[30] In an uncertain trading environment, traders prefer to stop operations in order to avoid storage costs and delay compensation. Stakeholders should put additional efforts in providing accurate and timely information. However, the resilience of the global agri-food system cannot be uniquely evaluated by the stability of international trade flows. For certain supply shocks, trade policy measures can only mitigate the impact, but additional actions must be considered for long-standing resilient markets. The agri-food system encompasses other activities, from post-harvest and storage to distribution and marketing (FAO, 2021b). Labour shortages were felt among agricultural input and food processing manufacturers, and throughout the distribution network. Understanding how each of these activities adjusted to the COVID-19 pandemic is an area for future research. However, trade has the capacity to respond to other pressing challenges on food supply chains. This includes providing a better access to nutritious food to the growing population, stable livelihoods for farmers and food producers, and an environmentally sustainable system.[31] For example, there is evidence about the vulnerability of the system to demographic growth (Suweis et al., 2015). This study does

[29] Mckinsey & Co published a few months after the onset of the pandemic a report showing sectors' exposure to shocks in global value chains: https://www.mckinsey.com/capabilities/operations/our-insights/risk-resilience-and-rebalancing-in-global-value-chains

[30] Indian rice exports suspended on supply chain disruption. Reuters, 3 April 2020. Accessible at https://www.reuters.com/article/us-health-coronavirus-india-food-exclusi-idUSKBN21L1XX

[31] These issues are defined by OECD (2021) as the long-term triple challenge.

not intend to assess how trade policies during the pandemic have affected these issues. Lee and Prabhakar (2021) provide a statistical review on NTMs during the pandemic on some of these issues. Future empirical studies may aim at these areas of research.

A set of policy recommendations can be framed from our study. Despite their limited impact on agricultural trade, export restrictions are still harmful, and they should be avoided as much as possible. Export bans and prohibitions not only impede trade, but also contribute to price spikes, unreasonable stocking, smuggling, and reducing product quality, all with severe consequences for the most vulnerable countries (Bown, 2020). Countries highly dependent on imports to fill their domestic food markets should rethink their portfolio of food providers and consider diversification strategies, prioritizing partners that do not tend to impose export restrictions. Governments can increase the resilience of domestic food supply chains not only through an increase in the productivity of domestic farmers, but also through the diversification of trade partners for other products. Diversification across partners, products and varieties helps to alleviate potential effects on domestic food systems from shocks originating in international markets.

Our figures also highlight the capacity of trade facilitation to keep a smooth trading environment even in periods of crisis. Governments must identify which of trade-promoting measures can be kept in the long-term, and which others should be added to action plans to reduce trade inefficiencies in future crises. Although it is difficult to find consensus in the multilateral fora on a full elimination of tariffs, particularly in sensitive subsectors, tariff reduction is an effective instrument to quickly address potential economic barriers to the import of products in periods of crisis. Countries could agree on mutual reduction of tariffs in highly protected sectors in periods of trade instability as an emergency measure. Among the measures that could be maintained on a regular basis is the acceptance of electronic certificates and an update of the international trade law for the validation of digital tools. There is an evident need for a technological transformation in the sector. Temporary electronic documentation schemes, such as platforms for generating and validating certificates, have helped minimize trade flow downturns. Their effectiveness has been proved by eliminating unnecessary time and administrative costs in complying with SPS regulation during the COVID-19 pandemic. Public and private stakeholders must jointly design investment strategies to eliminate bottlenecks throughout the food supply chain that can be resolved with technology. This policy strategy should include a plan for the automation of production, manufacturing and distribution tasks. Labour-intensive industries like meat and dairy have shown higher vulnerability, and automation can contribute to mitigate the impact of labour shortages in future pandemics (Weersink et al., 2021). Finally, technological progress can significantly reduce timings in the supply chain. Existing evidence points to a negative association between longer "time to export" and international trade flows (Heid et al., 2021).

Beyond trade policies, our work on trade policy compilation highlights the need for further work on market transparency and coordination. Trade policy interventions are difficult to track. The WTO notification system provides a platform to inform other members about new trade measures. However, not all regulation affecting trade is reported, while some notifications are not timely reported or updated (Wolfe, 2020). Moreover, sometimes the information is not updated or the product and time coverage is not clear enough. An enhanced multilateral monitoring mechanism also provides equal access to information, so all nations have the same opportunities to benefit from trade facilitation and adjust faster to changes in regulation. .

Conclusion

This thesis has empirically inspected contemporary issues that can impede the good functioning of global agri-food markets. I have chosen the topic of regulation and trade in agriculture because of its important implications for our society, as they go beyond the food security and livelihoods of millions of people working in the food supply chain. NTMs are designed to connect different policy areas and must become a key factor in meeting the targets set by the Sustainable Development Goals (De Melo and Nicita, 2018a). With globalization set at full speed, societies are rapidly evolving, and rules deemed indispensable today might be superfluous tomorrow.

The number and complexity of NTMs has grown substantially over time. In Chapter 1, I first attempt to review how current food standards align with one of the key principles of the multilateral trading system, non-discrimination. I therefore start by estimating the relative change in imports compared to domestic trade once a technical measure is introduced. Without a proper evaluation, standards can have a misleading interpretation of their neutrality.[32] All trading partners must comply with the regulation, however, countries' infrastructure is not equally developed and meeting the requirements can lead to heterogeneous compliance costs. Additionally, foreign exporters occasionally have been given less time to adapt their production processes than local producers (Cadot et al., 2018). I test the assumption that

[32] This is only partly true, as the WTO agreement includes provisions for rules that can be applied to a set of countries, such as antidumping and countervailing measures.

NTMs might be discriminatory in practice by using the structural gravity equation and incorporating intra-trade data – previously calculated from FAO food balance sheets–. The variables of interest for SPS and TBT measures are interacted with a dummy signalling whether the trade is happening internationally or domestically.

The interaction parameters do not specify if food standards are hampering the trade of those goods, but to what extent it is diverted in favour of domestic producers. In general terms, SPS measures do not seem to discriminate for foreign exporters, while we observe foreign producers losing market in favour of domestic producers when there is a new TBT measure. A more in-depth analysis provides additional reasons for concern. More specifically, I observe some areas of concern in the time trend and cross-country heterogeneous impact of standards. First, the estimates after the food price crisis of 2007-08 are negative and statistically significant, pointing to a growing trend in implementing discriminatory measures in recent years. Second, the coefficients are significantly negative for low-income countries. This might be explained by developed countries imposing indiscriminately stringent standards or, as stated before, poor infrastructure and planning in the poorest countries. The latter acknowledges the importance of trade facilitation programmes in developing economies, enabling exporters to enjoy full market access in developed countries. These findings also suggest the need for advanced monitoring and evaluation programmes to identify measures that significantly distort the effects of trade. The regression on Specific Trade Concerns does suggest that the WTO's notification mechanism works and members complaining about certain measures have grounded reasons to do so.

I have decided to give a central role to the interlinkage between trade and public health in the last two chapters because they have never been so connected before. Interdisciplinary research is still lagging behind the need to fully understand issues that affect both strands of policy action. In Chapter 2, I explore the impact of trade on public health in the absence of regulation. In particular, I hypothesize that a deregulated market can lead to overconsumption of junk food, with its negative consequences over obesity and public health budgets. The focus is on imports of soda and junk food as well as investment inflows in the food manufacturing sector from the US into Latin American countries. The assumption is that this commercial interaction with the US, a major producer of unhealthy food, can have an indirect impact –thus, acting as a mediator– on the growing obesity costs observed in Latin America. After constructing the obesity cost variable that allows for cross-country comparison, I test this assumption for the three mediators –imports of soda, imports of junk food and investment in food manufacturing–. The average causal mediation effect is positive and significant for the imports of these goods, while the indirect effect of investment is significant but almost negligible. Imports of junk food require special attention, as nearly half of the effect on the costs of obesity is explained through the increase in imports.

As the obesity pandemic is spiralling around the world, the results suggest that governments need to take prompt action to halt it. Standards already proved to be a powerful tool to curb smoking habits (Labonté et al., 2011).[33] McGrady (2011a) already explored this question from the legal perspective. After inspecting the compatibility of WTO agreements with domestic regulation, the author advocates for an overhaul upon two main aspects. First, he observes a regulatory chill, in the sense that the lack of clear regulatory boundaries may be leading WTO members not to implement certain lawful health measures. Second, the WTO Agreement is designed in a way that puts market access ahead when evaluating the legitimacy of NTMs. It is then clear that multilateral negotiations should address this issue and provide assurance that government action is compatible with international commitments. As McGrady concludes, health instruments should be considered in cases of potential dispute settlements regarding food, such as consumption and custom taxes or certain marketing practices of food products, particularly those targeting children. This type of provision can

[33] The Framework Convention on Tobacco Control (FCTC), provides an international legal umbrella under the premise of human health protection, allowing WHO member states to implement trade and investment control policies in tobacco.

also be incorporated in second-generation trade agreements, as they evolve towards more inclusive deals that include other socioeconomic issues. Ultimately, governments can also benefit in the long run from new trade rules that tackle the consumption of unhealthy food by reducing pressure on public health budgets.

In Chapter 3, I switch the focus and test the effects of a public health shock on trade policy action. In the context of the COVID-19 crisis, I explore how international markets reacted to new measures imposed by countries in an attempt to stabilize domestic markets. There is evidence that, as the COVID-19 pandemic evolved, governments made additional policy decisions over import facilitating and export restricting NTMs in the agri-food sector (Ahn and Steinbach, 2021). Using the gravity model and monthly trade flows, I estimate the overall effects of policy intervention in international markets, but also disaggregated by geographic areas and food groups. Although the results vary across regions and commodities, there are some general conclusions. Unlike the food price crisis in 2007-08, the gravity estimates indicate that export restrictions had only partial effects on the global food system. Still, the most affected countries by export bans were low-income countries and import-dependent countries. This is worrisome for food security reasons. Cereal imports, a key staple in the diets of the poorest countries, were distorted in the domestic markets of net importers. Trade intervention during the COVID-19 pandemic also had implications for nutrition, as international trade of fruits was hampered by export restrictions.

On the positive side, the results also highlight the important role of tariff reductions and other import facilitating measures during the COVID-19 crisis to keep basic food flowing around the world. Market policies that can reduce trade costs are essential to make global food markets more resilient to shocks. As Timmer (2017) explains, trade policy instruments need to operate compatibly with market prices as much as possible to keep the balance between consumer prices and the income of food producers. One policy with the capacity to benefit stakeholders throughout the supply change is the introduction of digital documents. For example, countries like Chile and Colombia launched electronic phytosanitary certificates.[34]

Limitations and Future research

As a result of my work in the three chapters, I have identified several areas for future research on trade regulation. A grey area hampering the proper assessment of trade policies is the lack of transparency. Not all governments notify the full details of their policy interventions. It is often difficult to determine what is the product coverage of trade measures. Nonetheless, what it makes particularly difficult to obtain an accurate evaluation of measures is the lack of updates or better clarification on the durability of measures. This is a major issue already acknowledged by UNCTAD (2018). When using panel data, there is no alternative to assuming that many measures extend over years unless notified, but this assumption is far from optimal.

Measures also need to gain in transparency. Governments should agree on higher standards in timeliness and quality of information. There is also little information on private standards that can reshape both international and domestic markets. In some industries, groups of private stakeholders that account for a large share of exports get together and set private standards with the aim to complement the existing public regulation. For example, the Roundtable on Sustainable Palm Oil (RSPO) is an organization conceived to establish the sustainability commitments in the palm oil industry throughout the supply chain. However, this organization has been criticized for its slow progress and failure to meet its commitments in certain issues, like deforestation (Gatti and Velichevskaya, 2020). Similar to the RSPO, there are thousands of other private standards for which the lack of data does not allow for monitoring and evaluation practices.

[34] Chile notified the acceptance of electronic certificates to WTO on 2nd April 2020 (G/SPS/GEN/1770), while Colombia did so on 21st July 2020 (G/SPS/GEN/1817/Rev.1).

Better information is also needed for the proper evaluation of obesity and nutrition. Future household surveys should incorporate more details on consumption patterns as well as physical activity, another decisive factor in understanding the obesity pandemic. Despite some health surveys attempt to cover these questions, the information is still insufficient, and the lack of survey standardization makes it incomparable across countries.

Finally, I believe that further research should aim at understanding the benefits and applications of digital transformation in trade and agriculture. For example, a resilient agri-food system must reduce dependence on labour supply, particularly in countries with investment muscle. The COVID-19 crisis has exhibited the vulnerability of global markets to labour shortages, and experts appeal for a higher degree of automation (Weersink et al., 2021). Adaptation to digital technologies can be another major catalyst for trade in the coming years by minimizing administrative costs, improving tracking systems, and reducing time at border checkpoints. In other words, they can be a major catalyst for trade facilitation. Tools like distributed ledger technology, or DLT, can positively disrupt several areas of international trade. Blockchain is a highly transparent technology with the capability to track products from farm to fork. An enhanced trace and tracking system is fundamental for agri-food trade, such as food safety –a major concern during the COVID-19 crisis in the livestock industry–, tracking of commodities' carbon footprint and complying with rules of origin. Similarly, they can track which products marked as highly caloric or unhealthy cross a border, providing real-time accurate statistics about junk food trade. Cost-benefit analyses should explore the application of these technologies to adapt the multilateral trading system to the capacities and needs of a globalized society.

Appendix One

Appendix Chapter One

A.1 Country coverage comparison

The table below compares the dataset cleaned and managed by the authors from the larger UNCTAD database (*Reg1*) and the readily available Stata file at UNCTAD website (*UNCTAD*).

Code	Country	Reg1	UNCTAD	Code	Country	Reg1	UNCTAD
AFG	Afghanistan	X	X	ECU	Ecuador		X
ATG	Antigua and Barbuda	X	X	SLV	El Salvador		X
ARG	Argentina		X	EST	Estonia	X	X
AUS	Australia	X	X	EUN	European Union	X	X
AUT	Austria	X	X	FIN	Finland	X	X
BHR	Bahrain	X	X	FRA	France	X	X
BGD	Bangladesh	X	X	GMB	Gambia	X	X
BRB	Barbados	X	X	DEU	Germany	X	X
BEL	Belgium	X	X	GHA	Ghana	X	X
BEN	Benin	X	X	GRC	Greece	X	X
BOL	Bolivia		X	GRD	Grenada	X	X
BWA	Botswana	X	X	GTM	Guatemala		X
BRA	Brazil		X	GIN	Guinea	X	X
BRN	Brunei Darussalam	X	X	GUY	Guyana	X	X
BGR	Bulgaria	X	X	HND	Honduras		X
BFA	Burkina Faso	X	X	HUN	Hungary	X	X
CPV	Cabo Verde	X	X	IND	India	X	X
KHM	Cambodia	X	X	IDN	Indonesia	X	X
CMR	Cameroon	X	X	IRL	Ireland	X	X
CAN	Canada	X	X	ISR	Israel	X	X
CHL	Chile		X	ITA	Italy	X	X
HKG	China, Hong Kong	X	X	JAM	Jamaica	X	X
CHN	China, mainland	X	X	JPN	Japan	X	X
COL	Colombia		X	JOR	Jordan	X	X
CRI	Costa Rica		X	KAZ	Kazakhstan	X	X
HRV	Croatia	X	X	KWT	Kuwait	X	X
CUB	Cuba		X	KGZ	Kyrgyzstan	X	X
CYP	Cyprus	X	X	LAO	Lao PDR	X	X
CZE	Czechia	X	X	LVA	Latvia	X	X
CIV	Côte d'Ivoire	X	X	LBR	Liberia	X	X
DNK	Denmark	X	X	LTU	Lithuania	X	X
DMA	Dominica	X	X	LUX	Luxembourg	X	X

Code	Country	Reg1	UNCTAD	Code	Country	Reg1	UNCTAD
MYS	Malaysia	X	X	ROU	Romania	X	X
MLI	Mali	X	X	RUS	Russian Fed.	X	X
MLT	Malta	X	X	SAU	Saudi Arabia	X	X
MRT	Mauritania	X	X	SEN	Senegal	X	X
MUS	Mauritius	X	X	SGP	Singapore	X	X
MEX	Mexico		X	SVK	Slovakia	X	X
MAR	Morocco	X	X	SVN	Slovenia	X	X
MMR	Myanmar	X	X	ESP	Spain	X	X
NPL	Nepal	X	X	LKA	Sri Lanka	X	X
NLD	Netherlands	X	X	SUR	Suriname	X	X
NZL	New Zealand	X	X	SWE	Sweden	X	X
NIC	Nicaragua		X	CHE	Switzerland	X	X
NER	Niger	X	X	TJK	Tajikistan	X	X
NGA	Nigeria	X	X	THA	Thailand	X	X
OMN	Oman	X	X	TGO	Togo	X	X
PAK	Pakistan	X	X	TTO	T&T	X	X
PAN	Panama		X	TUN	Tunisia	X	X
PNG	Papua New Guinea	X	X	TUR	Turkey	X	X
PRY	Paraguay		X	ARE	U.A.E	X	X
PER	Peru		X	GBR	UK	X	X
PHL	Philippines	X	X	USA	United States	X	X
POL	Poland	X	X	URY	Uruguay		X
PRT	Portugal	X	X	VEN	Venezuela		X
QAT	Qatar	X	X	VNM	Viet Nam	X	X
KOR	Rep.Korea	X	X	ZWE	Zimbabwe	X	X

A.2 Analysis of the non-discrimination principle by food groups.

The following regressions present the same specification as Table 1.1, but the sample has been reduced to a selection of food groups.

Table A.1: Differentiated impact of SPS and TBT Measures by food group, one-year lag.

	(1) Animals & Products	(2) Cereals	(3) Fruits	(4) Vegetables & Plants	(5) Other
log tariffs	-0.0099	-0.0298	-0.0348**	-0.0275*	-0.0280**
	(0.0209)	(0.0241)	(0.0161)	(0.0143)	(0.0124)
SPS × Int. Border	-0.3816**	0.3496	0.0425	0.0378	0.6402***
	(0.1756)	(0.2497)	(0.1322)	(0.1640)	(0.2082)
importer SPS measure	0.1602	0.3403	-0.0758	-0.1072	-0.6315***
	(0.1738)	(0.2940)	(0.1336)	(0.1643)	(0.2122)
TBT × Int. Border	0.2477	0.1961	-0.3971***	0.0427	1.0201**
	(0.2089)	(0.1938)	(0.0787)	(0.1098)	(0.4160)
importer TBT measure	-0.1975	-0.3588*	0.4215***	0.1109	-1.0238**
	(0.2167)	(0.2135)	(0.0868)	(0.1169)	(0.4176)
FTA with SPS/TBT prov.	-0.0774	-0.0292	0.0060	-0.0138	0.0518
	(0.0721)	(0.0640)	(0.0295)	(0.0351)	(0.0334)
Country-Pair FEs	yes	yes	yes	yes	yes
Pseudo R-squared	0.9987	0.9975	0.9967	0.9985	0.9900
Number of observations	171,304	178,124	225,741	297,305	516,855

Note: Gravity estimation using data on domestic demand. Columns are reported using a PPML estimator. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2: Differentiated impact of SPS and TBT Measures by food group, three-year lag.

	(1) Animals & Products	(2) Cereals	(3) Fruits	(4) Vegetables & Plants	(5) Other
log tariffs	-0.0099	-0.0298	-0.0348**	-0.0275*	-0.0280**
	(0.0209)	(0.0241)	(0.0161)	(0.0143)	(0.0124)
SPS × Int. Border	-0.3816**	0.3496	0.0425	0.0378	0.6402***
	(0.1756)	(0.2497)	(0.1322)	(0.1640)	(0.2082)
importer SPS measure	0.1602	0.3403	-0.0758	-0.1072	-0.6315***
	(0.1738)	(0.2940)	(0.1336)	(0.1643)	(0.2122)
TBT × Int. Border	0.2477	0.1961	-0.3971***	0.0427	1.0201**
	(0.2089)	(0.1938)	(0.0787)	(0.1098)	(0.4160)
importer TBT measure	-0.1975	-0.3588*	0.4215***	0.1109	-1.0238**
	(0.2167)	(0.2135)	(0.0868)	(0.1169)	(0.4176)
FTA with SPS/TBT prov.	-0.0774	-0.0292	0.0060	-0.0138	0.0518
	(0.0721)	(0.0640)	(0.0295)	(0.0351)	(0.0334)
Country-Pair FEs	yes	yes	yes	yes	yes
Pseudo R-squared	0.9987	0.9975	0.9967	0.9985	0.9900
Number of observations	171,304	178,124	225,741	297,305	516,855

Note: Gravity estimation using data on domestic demand. Columns are reported using a PPML estimator. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

A.3 Robustness Tests Table 1.1: individual regressions for SPS and TBT

Table A.3: Regressions from Table 1.1, only SPS measures.

	(1) Cross-section (t=2015)	(2) Panel	(3) Pair FEs	(4) OLS	(5) Res_OLS1
log tariffs	-0.2275***	-0.1447***	-0.1462***	-0.1538***	-0.0548***
	(0.0377)	(0.0350)	(0.0361)	(0.0387)	(0.0071)
SPS × Int. Border	0.2354	0.1304	0.1255	0.0879	-0.1380
	(0.3103)	(0.1983)	(0.2084)	(0.2221)	(0.1058)
importer SPS measure	-0.2972	-0.1542	-0.1504	-0.1226	0.3018***
	(0.3037)	(0.2112)	(0.2162)	(0.2283)	(0.1066)
log distance	-0.2648***				
	(0.0645)				
contiguity	0.3718**				
	(0.1772)				
common language	0.4297***				
	(0.1100)				
colonial links	-0.0384				
	(0.1638)				
provisions on SPS	0.4483***	0.0665*	0.0718**	0.0356	0.0402**
	(0.1140)	(0.0375)	(0.0363)	(0.0367)	(0.0180)
Int. Border	-3.2171***				
	(0.3373)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4098
Pseudo R-squared	0.8173	0.8541	0.8537	0.8502	
Number of observations	161,012	2,170,182	1,500,200	1,173,300	1,986,804

Note: Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-time and exporter-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.4: Regressions from Table 1.1, only TBT measures.

	(1) Cross-section (t=2015)	(2) Panel	(3) Pair FEs	(4) OLS	(5) Res_OLS1
log tariffs	-0.2307***	-0.1420***	-0.1431***	-0.1517***	-0.0553***
	(0.0388)	(0.0352)	(0.0363)	(0.0390)	(0.0071)
TBT × Int. Border	0.4079	-0.2417**	-0.2664**	-0.2739**	-0.0034
	(0.3394)	(0.1122)	(0.1164)	(0.1170)	(0.1156)
importer TBT measure	-0.1895	0.0626	0.0785	0.1014	0.1198
	(0.4709)	(0.0899)	(0.0935)	(0.0978)	(0.1181)
log distance	-0.2522***				
	(0.0646)				
contiguity	0.4155**				
	(0.1827)				
common language	0.4600***				
	(0.1086)				
colonial links	-0.0677				
	(0.1606)				
provisions on TBT	0.2880***	0.0583	0.0567	0.0169	0.0336*
	(0.1035)	(0.0360)	(0.0350)	(0.0343)	(0.0174)
Int. Border	-3.5509***				
	(0.3543)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4097
Pseudo R-squared	0.8169	0.8541	0.8537	0.8503	
Number of observations	161,012	2,170,182	1,500,200	1,173,300	1,986,804

Note: Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-time and exporter-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

A.4 Other Robustness Regressions for Table 1.1

Table A.5: Regression in Table 1.1 using EU aggregate.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2234*** (0.0507)	-0.1355*** (0.0497)	-0.1332*** (0.0511)	-0.1415*** (0.0545)	-0.0807*** (0.0094)
SPS × Int. Border	0.2492 (0.3323)	0.2093 (0.2589)	0.2047 (0.2826)	0.1462 (0.3144)	-0.2047 (0.1551)
importer SPS measure	-0.4123 (0.2983)	-0.2840 (0.2479)	-0.2849 (0.2628)	-0.2610 (0.2891)	0.2767* (0.1543)
TBT × Int. Border	0.3886 (0.3728)	-0.3950** (0.1758)	-0.4167** (0.1867)	-0.4151** (0.1900)	-0.0695 (0.1821)
importer TBT measure	-0.0716 (0.5061)	0.1191 (0.1315)	0.1340 (0.1447)	0.1472 (0.1549)	0.0965 (0.1826)
log distance	-0.4013*** (0.0858)				
contiguity	0.1608 (0.1949)				
common language	0.4937*** (0.1365)				
colonial links	-0.4717 (0.4578)				
FTA with SPS/TBT prov.	0.3548*** (0.1306)	0.0606 (0.0459)	0.0677 (0.0455)	-0.0010 (0.0485)	0.0391* (0.0215)
Int. Border	-3.2717*** (0.4443)				
				(0.3144)	
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4603
Pseudo R-squared	0.8392	0.8714	0.8698	0.8662	
Number of observations	79,677	1,053,969	700,146	534,913	955,698

Note: Gravity model using data on domestic demand (when $i = j$). Columns (1) to (4) report PPML estimates, and column (5) the OLS estimate. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.6: Regressions from Table 1.1 using UNCTAD data file.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2008***	-0.1338***	-0.1335***	-0.1405***	-0.0526***
	(0.0356)	(0.0307)	(0.0313)	(0.0338)	(0.0062)
SPS x Int. Border	-0.0789	0.2085	0.2123	0.1838	-0.2217
	(0.3020)	(0.2376)	(0.2572)	(0.2824)	(0.1446)
importer SPS measure	-0.1944	-0.2201	-0.2232	-0.1980	0.3505**
	(0.3275)	(0.2487)	(0.2639)	(0.2887)	(0.1445)
TBT x Int. Border	0.3184	-0.2797*	-0.3082*	-0.3048*	0.1064
	(0.3134)	(0.1619)	(0.1742)	(0.1803)	(0.1589)
importer TBT measure	-0.1421	0.0951	0.1121	0.1243	-0.0208
	(0.4470)	(0.1373)	(0.1497)	(0.1586)	(0.1601)
log distance	-0.2727***				
	(0.0558)				
contiguity	0.3727**				
	(0.1617)				
common language	0.5135***				
	(0.1040)				
colonial links	-0.1185				
	(0.1605)				
FTA with SPS/TBT prov.	0.4108***	0.0570*	0.0591*	0.0202	0.0516***
	(0.0867)	(0.0310)	(0.0310)	(0.0327)	(0.0157)
Int. Border	-3.2621***				
	(0.2239)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4145
Pseudo R-squared	0.8155	0.8518	0.8507	0.8470	
Number of observations	184,873	2,535,948	1,757,619	1,380,096	2,311,185

Note: Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-time and exporter-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.7: Regression in Table 1.1 using sub-sample where FAOSTAT and HS product codes match perfectly.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2404***	-0.1683***	-0.1708***	-0.1772***	-0.0680***
	(0.0405)	(0.0351)	(0.0356)	(0.0384)	(0.0079)
SPS x Int. Border	0.2009	0.2301	0.2249	0.1984	-0.2144
	(0.3611)	(0.2552)	(0.2720)	(0.2926)	(0.1510)
importer SPS measure	-0.3355	-0.1969	-0.1970	-0.1742	0.4533***
	(0.3486)	(0.2602)	(0.2712)	(0.2917)	(0.1509)
TBT x Int. Border	0.3030	-0.2701*	-0.2907*	-0.2802*	0.1292
	(0.3607)	(0.1468)	(0.1549)	(0.1570)	(0.1650)
importer TBT measure	-0.1234	-0.0067	0.0048	0.0172	-0.0007
	(0.4964)	(0.1132)	(0.1204)	(0.1266)	(0.1665)
log distance	-0.2366***				
	(0.0677)				
contiguity	0.4286**				
	(0.1867)				
common language	0.4033***				
	(0.1153)				
colonial links	-0.0005				
	(0.1711)				
FTA with SPS/TBT prov.	0.2961***	0.0724*	0.0769*	0.0438	0.0521***
	(0.1051)	(0.0389)	(0.0392)	(0.0389)	(0.0180)
Int. Border	-3.6826***				
	(0.4080)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.3641
Pseudo R-squared	0.8081	0.8455	0.8445	0.8407	
Number of observations	118,159	1,574,968	1,062,374	822,921	1,406,983

Note: Gravity estimation using data on domestic demand. Intra-national trade is accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. All estimates include importer-time and exporter-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.8: Regression reported in Table 1.1 using simple averaged tariffs.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2906***	-0.1775***	-0.1695***	-0.1732***	-0.1371***
	(0.0527)	(0.0488)	(0.0517)	(0.0560)	(0.0081)
SPS x Int. Border	0.1057	0.1705	0.1550	0.1031	-0.2930*
	(0.3428)	(0.2486)	(0.2688)	(0.2984)	(0.1558)
importer SPS measure	-0.3197	-0.2431	-0.2451	-0.2218	0.3716**
	(0.3116)	(0.2445)	(0.2590)	(0.2862)	(0.1553)
TBT x Int. Border	0.4324	-0.3244*	-0.3467*	-0.3526*	-0.0506
	(0.3781)	(0.1662)	(0.1770)	(0.1811)	(0.1842)
importer TBT measure	-0.1913	0.0869	0.1024	0.1198	0.0957
	(0.4988)	(0.1310)	(0.1427)	(0.1517)	(0.1847)
log distance	-0.3797***				
	(0.0760)				
contiguity	0.1887				
	(0.1881)				
common language	0.4687***				
	(0.1242)				
colonial links	0.0316				
	(0.2380)				
FTA with SPS/TBT prov.	0.2490**	0.0462	0.0535	0.0067	0.0143
	(0.1215)	(0.0501)	(0.0497)	(0.0485)	(0.0191)
Int. Border	-3.2506***				
	(0.4143)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.4519
Pseudo R-squared	0.8328	0.8662	0.8648	0.8612	
Number of observations	112,897	1,489,463	991,259	759,777	1,357,929

Note: Gravity estimation using data on domestic demand. Intra-national trade is accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. All estimates include importer-time and exporter-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

A.5 Regressions using sub-sample where FAOSTAT and HS product codes perfectly match.

Table A.9: Estimates for regression in Table 1.7 sub-sampling by product codes with perfect match.

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0193	-0.0295**	-0.0308**	-0.0329**	-0.0347***
	(0.0125)	(0.0120)	(0.0129)	(0.0142)	(0.0108)
SPS with concern	-0.0869***	-0.0399	0.0047	-0.0199	-0.0096
	(0.0328)	(0.0368)	(0.0367)	(0.0310)	(0.0339)
TBT with concern	-0.1038***	-0.0390*	-0.0369	0.2073***	0.0134
	(0.0344)	(0.0219)	(0.0233)	(0.0428)	(0.0248)
FTA with SPS/TBT prov.	0.0742***	0.0907***	0.0819***	0.0762**	0.0873***
	(0.0284)	(0.0297)	(0.0289)	(0.0323)	(0.0292)
Country-pair FEs	yes	yes	yes	yes	yes
R-squared					0.8996
Pseudo R-squared	0.9881	0.9887	0.9898	0.9913	
Number of observations	522,996	384,631	308,468	221,089	481,638

Note: Gravity estimation with intra-national trade accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the importer-product level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.10: Estimates for regression in Table 1.8 sub-sampling by product codes with perfect match.

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0167	-0.0269*	-0.0130	-0.0196	-0.0350**
	(0.0165)	(0.0157)	(0.0169)	(0.0158)	(0.0156)
Country Raising	-0.0704**	-0.0043	-0.0269	-0.0485	0.0164
	(0.0287)	(0.0336)	(0.0335)	(0.0387)	(0.0332)
provisions on SPS	-0.0195	0.0023	0.0039	0.0537	0.0195
	(0.0379)	(0.0389)	(0.0369)	(0.0418)	(0.0437)
Country-pair FEs	yes	yes	yes	yes	yes
R-squared					0.9036
Pseudo R-squared	0.9858	0.9864	0.9875	0.9891	
Number of observations	287,530	209,371	166,492	118,748	266,621

Note: All columns include importer-exporter-product fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.11: Estimates for regression in Table 1.9 sub-sampling by product codes with perfect match.

	(1) No Lags	(2) 1-Year Lag	(3) 3-Year Lag	(4) 6-Year Lag	(5) OLS
log tariffs	-0.0199**	-0.0234***	-0.0235**	-0.0168	-0.0429***
	(0.0090)	(0.0090)	(0.0099)	(0.0106)	(0.0058)
Country Supporting	-0.0009	0.0090	0.0359	0.0247	0.0242
	(0.0338)	(0.0344)	(0.0390)	(0.0423)	(0.0304)
provisions on SPS	0.0080	0.0196	0.0045	-0.0196	0.0357*
	(0.0225)	(0.0228)	(0.0246)	(0.0477)	(0.0195)
Country-pair FEs	yes	yes	yes	yes	yes
R-squared					0.8856
Pseudo R-squared	0.9842	0.9860	0.9874	0.9893	
Number of observations	1,306,442	880,360	669,834	465,464	1,189,409

Note: All columns include importer-exporter-product fixed effects. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

A.6 Sample of measures applied to all producers

Below we introduce a series of tests where we only use the sample of measures that UNCTAD identifies as applicable to domestic and import markets. These measures are traceable through the *Alsodomestic* variable equal to 1 when applied to all producers.

Table A.12: Relative Effect of SPS and TBT Measures on International Vs intra-national Trade.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.3016*** (0.0388)	-0.0281*** (0.0104)	-0.0311*** (0.0095)	-0.0388*** (0.0122)	-0.0418*** (0.0061)
SPS x Int. Border	0.4241* (0.2294)	-0.0736 (0.0652)	-0.0553 (0.0558)	-0.0376 (0.0321)	0.0736* (0.0411)
TBT x Int. Border	-0.0236 (1.0416)	0.0903* (0.0510)	0.1697** (0.0818)	0.1135 (0.0916)	0.1713** (0.0738)
log distance	-0.9584*** (0.0521)				
contiguity	0.4250*** (0.1235)				
common language	0.5637*** (0.0942)				
colonial links	-0.2496* (0.1483)				
FTA with SPS/TBT prov.	0.0201 (0.0852)	-0.0003 (0.0377)	0.0344 (0.0347)	0.0347 (0.0229)	0.0751*** (0.0217)
Int. Border	-3.3661*** (1.0504)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.9148
Pseudo R-squared	0.9765	0.9972	0.9973	0.9975	
Number of observations	57,002	1,238,735	863,576	644,203	1,258,599

Note: Gravity estimation using data on domestic demand accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. The dummy variable "FTA with SPS or TBT provisions" is equal to 1 when a trade agreement includes SPS and/or TBT provisions. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.13: Comparison of food standards before and after food price crisis (reference year = 2008).

	(1)	(2)	(3)	(4)	(5)	(6)
	Pre-crisis			Post-crisis		
	No Lags	1-Year Lag	3-Year Lags	No Lags	1-Year Lag	3-Year Lags
log tariffs	0.0350	0.0027	0.0465	-0.0420***	-0.0224**	-0.0540***
	(0.0294)	(0.0240)	(0.0527)	(0.0107)	(0.0109)	(0.0135)
SPS × Int. Border	-0.1828**	-0.1126**	-0.0319	-0.1596***	-0.1439***	0.0323
	(0.0786)	(0.0566)	(0.0505)	(0.0429)	(0.0417)	(0.0522)
TBT × Int. Border	0.1243**	0.0935	0.1502***	-0.0418	-0.1159**	-0.2560***
	(0.0489)	(0.0578)	(0.0334)	(0.0585)	(0.0579)	(0.0737)
FTA with SPS/TBT prov.	-0.0707	-0.0464	0.0151	-0.0051	0.0708**	0.0310
	(0.0660)	(0.0558)	(0.0239)	(0.0328)	(0.0316)	(0.0297)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
R-squared						
Pseudo R-squared	0.9982	0.9984	0.9986	0.9980	0.9982	0.9985
Number of observations	725,139	466,390	286,299	382,648	256,919	143,412

Note: Gravity estimation using data on domestic demand. All columns are reported using a PPML estimator and include importer-product-time and exporter-product-time fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt} and includes domestic demand when $i = j$. Pre-crisis period covers from 2000 to 2008, while post-crisis period goes from 2008 to 2016. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.14: Heterogeneous effect of SPS Measures across income groups.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper Middle		Low and Lower Middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0131	-0.0005	-0.0220**	-0.0174	-0.1287***	-0.0778*
	(0.0100)	(0.0164)	(0.0096)	(0.0131)	(0.0379)	(0.0453)
SPS × cross-group	-0.1218***	-0.0605	-0.1265***	-0.0799***	0.0585	-0.0835
	(0.0449)	(0.0495)	(0.0329)	(0.0268)	(0.1267)	(0.1498)
provisions on SPS	0.0679**	0.1001***	0.0684**	0.0909***	0.2591***	-0.0350
	(0.0309)	(0.0337)	(0.0293)	(0.0305)	(0.0781)	(0.1136)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9966	0.9969	0.9965	0.9965	0.9992	0.9992
Number of observations	584,455	437,426	713,963	528,454	107,430	71,867

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.15: Heterogeneous effect of TBT Measures across income groups.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper Middle		Low and Lower Middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0123	0.0001	-0.0202**	-0.0165	-0.1271***	-0.0787*
	(0.0101)	(0.0163)	(0.0098)	(0.0132)	(0.0380)	(0.0429)
TBT × cross-group	0.0770*	0.0240	0.0960**	0.0587*	-0.1369	-0.1858
	(0.0421)	(0.0370)	(0.0400)	(0.0315)	(0.0883)	(0.1453)
L.provisions on TBT	0.0819***	0.1102***	0.0829***	0.0998***	0.3295***	-0.0067
	(0.0307)	(0.0324)	(0.0292)	(0.0291)	(0.0913)	(0.1102)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9966	0.9969	0.9965	0.9965	0.9992	0.9992
Number of observations	584,455	437,426	713,963	528,454	107,430	71,867

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

A.7 Results for the tables reported in section 1.6 using Frequency Ratios

The Frequency Index captures a country's share of traded products at the four-digit level subject to at least one NTM. Due to the small number of STCs, we have excluded the estimation of Tables 7 to 9 using frequency ratios.

Table A.16: Relative Effect of SPS and TBT Measures on International Vs intra-national Trade.

	(1) Cross-section (t=2015)	(2) No Lags	(3) 1-Year Lag	(4) 3-Year Lag	(5) OLS
log tariffs	-0.2171*** (0.0319)	-0.0251*** (0.0086)	-0.0325*** (0.0083)	-0.0349*** (0.0093)	-0.0400*** (0.0052)
SPS freq. x Int. Border	-0.0507 (0.2362)	0.2445** (0.1102)	0.1625* (0.0844)	-0.1986 (0.1317)	0.3178*** (0.0891)
TBT freq. x Int. Border	0.4254 (0.3761)	0.0093 (0.0839)	0.1621 (0.1301)	0.1628 (0.2186)	0.3505*** (0.0842)
log distance	-0.9438*** (0.0396)				
contiguity	0.4508*** (0.1080)				
common language	0.4394*** (0.0730)				
colonial links	-0.0455 (0.0901)				
FTA with SPS/TBT prov.	0.1827*** (0.0637)	-0.0216 (0.0308)	0.0015 (0.0273)	0.0081 (0.0205)	0.0361** (0.0176)
Int. Border	-3.6586*** (0.3954)				
Border*year dummies	no	yes	yes	yes	no
Country-pair FEs	no	yes	yes	yes	yes
R-squared					0.9024
Pseudo R-squared	0.9728	0.9968	0.9970	0.9971	
Number of observations	154,170	1,918,975	1,337,268	1,038,068	1,784,545

Note: Gravity estimation using data on domestic demand accounted for when $i = j$. Columns (1) to (4) are reported using a PPML estimator, and column (5) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. The dummy variable "FTA with SPS or TBT provisions" is equal to 1 when a trade agreement includes SPS and/or TBT provisions. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.17: Comparison of food standards before and after food price crisis (reference year = 2008).

	(1)	(2)	(3)	(4)	(5)	(6)
		Pre-crisis			Post-crisis	
	No Lags	1-Year Lag	3-Year Lags	No Lags	1-Year Lag	3-Year Lags
log tariffs	0.0184	-0.0075	0.0101	-0.0215**	-0.0183*	-0.0406***
	(0.0249)	(0.0208)	(0.0437)	(0.0101)	(0.0103)	(0.0120)
Freq. SPS × Int. Border	0.2363	0.2228	0.1494	-0.0417	-0.1048	-0.1648
	(0.1717)	(0.2779)	(0.3050)	(0.0805)	(0.1117)	(0.1322)
Freq. TBT × Int. Border	0.4307***	0.9001	0.6972**	-0.1133	-0.1255	-0.4532***
	(0.1597)	(0.5742)	(0.2997)	(0.0899)	(0.0904)	(0.1552)
FTA with SPS/TBT prov.	-0.0375	-0.0271	0.0289	-0.0389	0.0036	-0.0373
	(0.0736)	(0.0584)	(0.0239)	(0.0275)	(0.0258)	(0.0284)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
R-squared						
Pseudo R-squared	0.9984	0.9986	0.9988	0.9975	0.9977	0.9979
Number of observations	869,065	561,795	346,712	853,127	553,728	316,629

Note: Gravity estimation using data on domestic demand. All columns are reported using a PPML estimator and include importer-product-time and exporter-product-time fixed effects. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt} and includes domestic demand when $i = j$. Pre-crisis period covers from 2000 to 2008, while post-crisis period goes from 2008 to 2016. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.18: Heterogeneous effect of SPS Measures across income groups.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper Middle		Low and Lower Middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0175*	-0.0000	-0.0162*	-0.0174	-0.1665***	-0.1064***
	(0.0101)	(0.0127)	(0.0090)	(0.0106)	(0.0316)	(0.0352)
Freq. SPS × cross-group	-0.1346***	-0.1300***	-0.0779***	-0.0785***	-0.0267	0.1871**
	(0.0385)	(0.0398)	(0.0285)	(0.0269)	(0.1035)	(0.0783)
provisions on SPS	0.0273	0.0664**	0.0359	0.0653**	0.1573**	-0.2417
	(0.0258)	(0.0277)	(0.0244)	(0.0257)	(0.0641)	(0.1525)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9952	0.9955	0.9955	0.9951	0.9992	0.9991
Number of observations	950,771	736,310	1,106,158	853,293	179,063	127,541

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table A.19: Heterogeneous effect of TBT Measures across income groups.

	(1)	(2)	(3)	(4)	(5)	(6)
	High income		High and Upper Middle		Low and Lower Middle	
	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags	1-Year Lag	3-Year Lags
log tariffs	-0.0147	0.0008	-0.0159*	-0.0166	-0.1630***	-0.1179***
	(0.0101)	(0.0127)	(0.0091)	(0.0106)	(0.0318)	(0.0338)
Freq. TBT × cross-group	0.0165	-0.1016***	0.0707**	0.0050	-0.0953	0.2089***
	(0.0366)	(0.0388)	(0.0299)	(0.0312)	(0.0687)	(0.0698)
provisions on TBT	0.0368	0.0704***	0.0469*	0.0695***	0.1877**	-0.1158
	(0.0259)	(0.0267)	(0.0244)	(0.0248)	(0.0742)	(0.1386)
Border*year dummies	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9952	0.9955	0.9955	0.9951	0.9992	0.9991
Number of observations	950,771	736,310	1,106,158	853,293	179,063	127,541

Note: All columns are reported using a PPML estimator. The dependent variable is bilateral trade flows in the agricultural sector at the four-digit product level from country i to country j, X_{ijpt}. Standard errors are clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Two

Appendix Chapter Two

B.1 List of pathologies and junk food products included in the study

- Diabetes mellitus type 2
- Hypertensive heart disease
- Ischaemic heart disease
- Intracerebral hemorrhage
- Subarachnoid hemorrhage
- Ischaemic stroke
- Breast cancer
- Colon and rectum cancer
- Kidney cancer
- Oesophageal cancer
- Pancreatic cancer
- Uterine cancer
- Osteoarthritis of the hip
- Osteoarthritis of the knee

Table B.1: List of sugar-sweetened beverages in the study, based on the NOVA classification

Sugar-Sweetened Beverages (SSBs)	
Product description	**HS 2007 six-digit codes**
Milk and cream containing added sugar	040210, 040229, 040299
Buttermilk, yogurt, kephir and other milk and cream containing added sugar	040310, 040390
Cocoa powder containing added sugar	180610
Juices, whether or not containing added sugar	200911, 200912, 200919, 200921, 200929, 200931, 200939, 200941, 200949, 200950, 200961, 200969, 200971, 200979, 200980, 200990
Waters (including carbonated) containing added sugar	220210
Non-alcoholic beverages	220290

Table B.2: List of ultra-processed foods in the study, based on the NOVA classification

Ultra-processed Food	
Product description	**HS 2007 six-digit codes**
Dairy produce derived from milk (butter, spreads, fats and oils)	040510, 040520, 040590
Sausages and other meat preparations	160100, 160210, 160220, 160231, 160232, 160239, 160241, 160242, 160249, 160250, 160290
Fish and crustacean preparations	160411, 160412, 160413, 160414, 160415, 160416, 160419, 160420, 160430, 160510, 160520, 160530, 160540, 160590
Cane or beet sugar	170111, 170112, 170191, 170199
Other sugars including sugar syrups, artificial honey and caramel	170211, 170219, 170220, 170230, 170240, 170250, 170260, 170290
Molasses	170310, 170390
Sugar confectionery (including white chocolate), not containing cocoa	170410, 170490
Chocolate and other food preparations containing cocoa (excl. cocoa powder)	180620, 180631, 180632, 180690
Bread, pastry, cakes, biscuits, other bakers' wares (inlc. pizzas)	190120, 190190, 190510, 190520, 190531, 190532, 190540, 190590
Cooked or prepared pasta	190230
Products obtained from cereals	190410, 190420, 190430, 190490
Not frozen potato preparations	200520
Jams, fruit jellies and marmalades	200710, 200791, 200799
Sauces, condiments and seasoning	210310, 210320, 210330, 210390
Ice cream	210500
Other food preparations, including protein concentrates	210610, 210690

B.2 Average estimates of obesity-related costs by country

Table B.3: Average estimates of obesity-related costs by country

	country	coo_pc1	coo_pc2	coo_pc3
1	Argentina	2,173	3,778	518
2	Barbados	1,769	2,834	389
3	Bolivia	1,055	1,938	274
4	Brazil	2,324	3,168	444
5	Chile	2,262	3,429	472
6	Colombia	1,827	3,349	471
7	Costa Rica	2,114	3,777	528
8	Ecuador	2,305	3,530	500
9	El Salvador	1,905	3,586	502
10	Guatemala	1,921	3,540	503
11	Honduras	1,979	3,649	519
12	Jamaica	2,689	4,394	611
13	Mexico	1,942	2,595	361
14	Nicaragua	1,813	3,085	436
15	Panama	2,910	4,875	686
16	Paraguay	1,399	2,514	355
17	Peru	796	1,437	203
18	Uruguay	1,389	1,845	252

Note: *coo1* refers to costs of obesity using all diseases from Appendix A and cost estimates from scenario 1 in Barcelo et al. (2017); *coo2* refers to costs of obesity using all diseases from Appendix A and cost estimates from scenario 1 in Barcelo et al. (2017); *coo3* refers to costs of obesity using only costs from diabetes type 2 and hypertension, taking estimates from scenario 2 from Barcelo et al. (2017). Figures are expressed in millions USD.

B.3 Linear regression analysis.

As explained by Baron and Kenny (1986), we need to demonstrate the existence of a relationship between the mediator M and the set of regressors X, as well as X and the output Y in order to be a case for mediation. This is shown in Tables B.4 and B.5 respectively. We complete the OLS estimation with Table B.6, as it helps to better understand the relationships among variables.

Table B.4: OLS regressions on costs of obesity

	CoO1	CoO2	CoO3
	(1)	(2)	(3)
US FTA (t-1)	0.0406	0.0780*	0.0930**
	(0.0421)	(0.0401)	(0.0412)
Urban Population (%)	−0.0060***	−0.0090***	−0.0096***
	(0.0018)	(0.0017)	(0.0017)
Log(total population)	1.1031***	1.1726***	1.1835***
	(0.0292)	(0.0278)	(0.0285)
Per Capita GDP (PPP)	0.0001***	0.0001***	0.0001***
	(0.000005)	(0.000005)	(0.000005)
Imports of other food	0.0001**	0.0001***	0.0001***
	(0.00003)	(0.00002)	(0.00003)
Manufact. imports	−0.00001***	−0.00001***	−0.00001***
	(0.000003)	(0.000002)	(0.000002)
Cultural Proximity	0.0088***	0.0124***	0.0127***
	(0.0027)	(0.0026)	(0.0026)
Literacy rate (% pop)	−0.0325***	−0.0310***	−0.0308***
	(0.0041)	(0.0039)	(0.0040)
Govt exp. final cons.	0.0390***	0.0331***	0.0336***
	(0.0061)	(0.0058)	(0.0060)
Constant	−6.2480***	−6.7999***	4.8781***
	(0.6084)	(0.5799)	(0.5955)
Observations	286	286	286
R^2	0.9737	0.9752	0.9741

Significance levels *p<0.1; **p<0.05; ***p<0.01

Table B.5: OLS regressions on junk food and SSBs consumption, and US investment in the food industry

	Log(Junk food imports)	Log(SSB imports)	US investment
	(1)	(2)	(3)
US FTA (t-1)	0.7362***	0.6631***	−101.0419***
	(0.1311)	(0.1929)	(28.0402)
Urban Population (	(0.0054)	(0.0080)	(1.1568)
Total population	0.0127***	0.0124***	6.8525***
	(0.0017)	(0.0025)	(0.3599)
Per Capita GDP (PPP)	0.0580***	0.0643***	6.2630*
	(0.0149)	(0.0219)	(3.1875)
Imports of other food	0.0940	0.1160	113.3224***
	(0.0850)	(0.1250)	(18.1730)
Manufact. imports	0.0089	0.0137	4.2438**
	(0.0088)	(0.0129)	(1.8818)
Cultural Proximity	0.0288***	0.0662***	0.6608
	(0.0060)	(0.0088)	(1.2857)
Literacy rate (	(0.0128)	(0.0188)	(2.7294)
Constant	9.9522***	23.4784***	25.1817
	(0.9626)	(1.4157)	(205.8226)
Observations	286	286	286
R^2	0.7038	0.6355	0.9472

Significance levels *p<0.1; **p<0.05; ***p<0.01

Table B.6: OLS regressions on costs of obesity

	Cost of Obesity		
	(1)	(2)	(3)
US FTA (t-1)	0.2590**	0.3207***	0.3848***
	(0.1005)	(0.0993)	(0.1090)
Junk food imports	0.2943***		
	(0.0377)		
SSB imports		0.2413***	
		(0.0316)	
US investment food sector			−0.0006***
			(0.0002)
Urban Population (%)	0.0147***	0.0122***	0.0129***
	(0.0041)	(0.0041)	(0.0044)
Total population	0.0068***	0.0073***	0.0117***
	(0.0017)	(0.0017)	(0.0024)
Per Capita GDP (PPP)	0.00004***	0.00005***	0.0001***
	(0.00001)	(0.00001)	(0.00001)
Imports of other food	0.0001**	0.0001**	0.0002***
	(0.0001)	(0.0001)	(0.0001)
Manufact. imports	−0.00002**	−0.00002**	−0.00001
	(0.00001)	(0.00001)	(0.00001)
Cultural Proximity	−0.0624***	−0.0637***	−0.0540***
	(0.0053)	(0.0054)	(0.0057)
Literacy rate (% pop)	−0.0109	−0.0091	−0.0492***
	(0.0106)	(0.0108)	(0.0103)
Govt exp. final cons.	0.0137	0.0335*	0.0721***
	(0.0194)	(0.0187)	(0.0196)
Constant	22.8009***	20.1137***	25.9593***
	(0.8134)	(1.0427)	(0.7703)
Observations	286	286	286
R^2	0.8552	0.8541	0.8276
Significance levels	*p<0.1; **p<0.05; ***p<0.01		

B.4 Robustness checks on the mediation estimates

B.4.1 Estimates combining imports of junk food and soft drinks as mediator

Table B.7: Causal Mediation Analysis - Junk Food and SSB Imports

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.21063***	0.1127	0.30	<2e-16
ADE	0.2571***	0.0959	0.40	<2e-16
Total Effect	0.4633***	0.2892	0.62	<2e-16
Prop. Mediated	0.4523***	0.2835	0.68	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

B.4.2 Estimates running 1000 simulations

Table B.8: Causal Mediation Analysis - Junk Food and SSB Imports (1000 simulations)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.2093***	0.1047	0.32	<2e-16
ADE	0.2639**	0.0983	0.44	<0.02
Total Effect	0.4732***	0.2739	0.68	<2e-16
Prop. Mediated	0.4461***	0.2609	0.70	<2e-16
Sample Size Used:	286			
Simulations:	1000			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table B.9: Causal Mediation Analysis - US investment (1000 simulations)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.06145*	0.00462	0.13	0.026
ADE	0.38756***	0.20471	0.57	<2e-16
Total Effect	0.44901***	0.26021	0.62	<2e-16
Prop. Mediated	0.13475*	0.00944	0.32	0.026
Sample Size Used:	286			
Simulations:	1000			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

B.4.3 Estimates using different lags on the FTA variable

Three-year lags

Table B.10: Causal Mediation Analysis - Junk Food and SSB Imports (3-year lags)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.2263***	0.1130	0.35	<2e-16
ADE	0.2170*	0.0557	0.39	0.02
Total Effect	0.4433***	0.2470	0.71	<2e-16
Prop. Mediated	0.5190***	0.3126	0.77	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged three years. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table B.11: Causal Mediation Analysis - US investment (3-year lags)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.05759$^{\cdot}$	0.00208	0.13	0.06
ADE	0.35691***	0.17313	0.55	<2e-16
Total Effect	0.41449***	0.26477	0.57	<2e-16
Prop. Mediated	0.12354$^{\cdot}$	0.00427	0.39	0.06
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged three years. Estimates using OLS. Dependent variable is estimates of obesity costs, *CoO3*. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Five-year lags

Table B.12: Causal Mediation Analysis - Junk Food and SSB Imports (5-year lags)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.1996***	0.1010	0.33	<2e-16
ADE	−0.0363	−0.2133	0.19	0.64
Total Effect	0.1613	−0.0621	0.35	0.16
Prop. Mediated	1.1559	−3.5488	11.62	0.16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged five years. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table B.13: Causal Mediation Analysis - US investment (5-year lags)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.0235	−0.0157	0.08	0.34
ADE	0.1127	−0.0692	0.31	0.26
Total Effect	0.1363	−0.0623	0.32	0.18
Prop. Mediated	0.1297	−0.7174	2.69	0.44
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged five years. Dependent variable is estimates of obesity costs, *CoO3*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

B.4.4 Estimates using other obesity costs estimates

Using *CoO1*

Table B.14: Causal Mediation Analysis - Junk Food and SSB Imports (Using *CoO1*)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.2141***	0.1259	0.32	<2e-16
ADE	0.2112***	0.0573	0.36	<2e-16
Total Effect	0.4253***	0.2258	0.59	<2e-16
Prop. Mediated	0.5060***	0.3107	0.80	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO1*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table B.15: Causal Mediation Analysis - US investment (Using *CoO1*)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.0595***	0.0159	0.11	<2e-16
ADE	0.3304***	0.1696	0.55	<2e-16
Total Effect	0.3900***	0.2252	0.58	<2e-16
Prop. Mediated	0.1578***	0.0376	0.34	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO1*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Using *CoO2*

Table B.16: Causal Mediation Analysis - Junk Food and SSB Imports (Using *CoO2*)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.2092***	0.1003	0.32	<2e-16
ADE	0.2570***	0.0928	0.42	<2e-16
Total Effect	0.4663***	0.2765	0.65	<2e-16
Prop. Mediated	0.4617***	0.2433	0.70	<2e-16
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO2*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table B.17: Causal Mediation Analysis - US investment (Using *CoO2*)

		Quasi-Bayesian Confidence Intervals		
	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.05999*	0.00474	0.12	0.04
ADE	0.37008***	0.21655	0.56	<2e-16
Total Effect	0.43008***	0.27790	0.63	<2e-16
Prop. Mediated	0.14359*	0.01110	0.30	0.04
Sample Size Used:	286			
Simulations:	100			

Note: FTA is lagged one year. Dependent variable is estimates of obesity costs, *CoO2*. Estimates using OLS. Significance levels: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

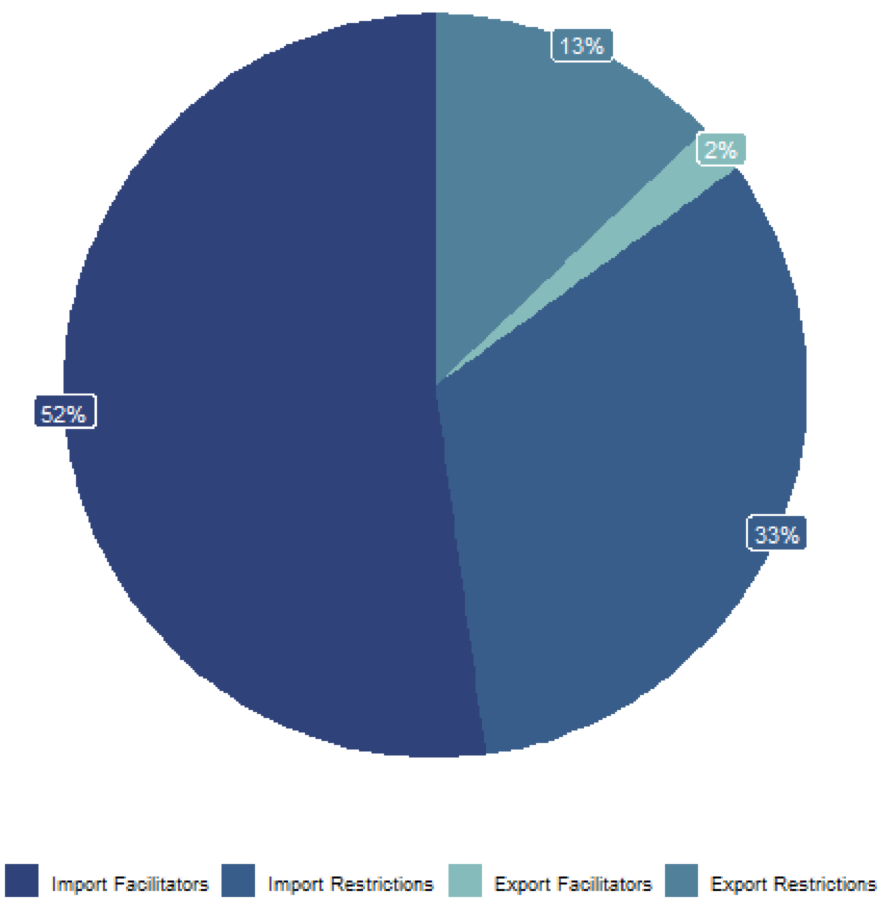
Appendix Three

Appendix Chapter Three

C.1 Descriptive analysis of COVID-19 trade measures.

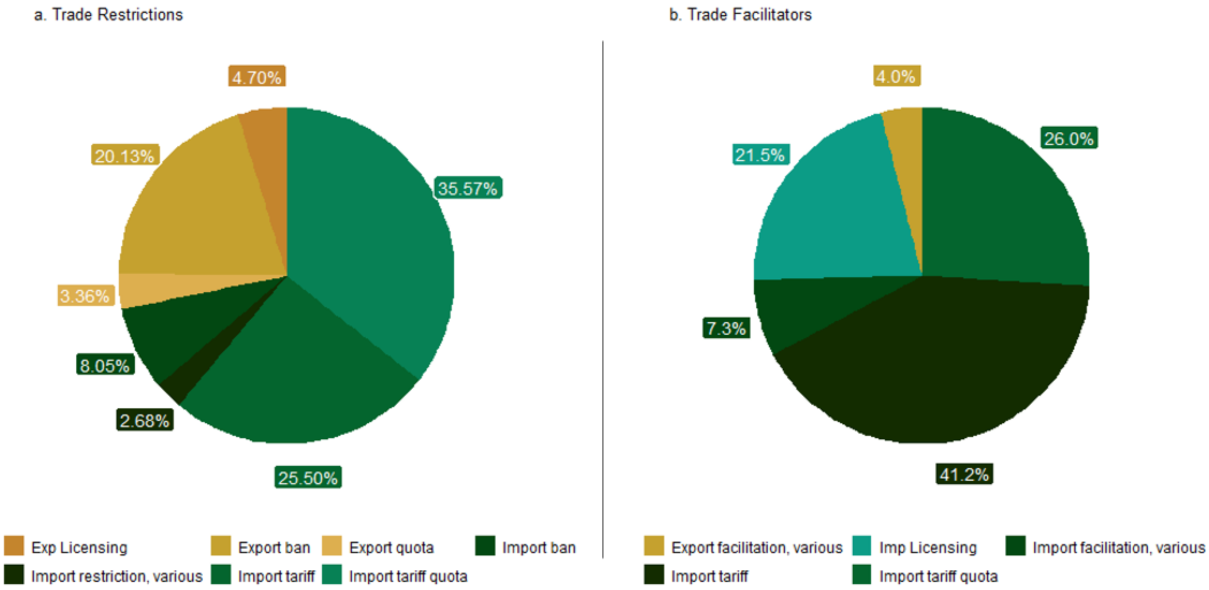
Below we present the shares of COVID-19 trade interventions, sorted by type of policy (Figure C.1) and by type of measures, and grouped by import and export policies (Figure C.2). The dataset used for the graph was built using information from WTO, ITC, FAO and the Global Trade Alert.

Figure C.1: Share of interventions by policy type



Sources: WTO, FAO, ITC and the Global Trade Alert.

Figure C.2: Share of import (a) and export (b) measures



Sources: Sources: WTO, FAO, ITC and the Global Trade Alert.

C.2 Tariff aggregation methodology

There are different approaches to aggregate tariffs in the literature. The most common ones take simple averages or calculate import-weighted averages. However, the former does not account for the relevance of each product in trade flows within each 4-digit heading. The latter tends to underestimate tariff restrictiveness when they are very high (Guimbard et al., 2012). We thus aggregate tariffs at the 4-digit level using country reference groups to minimize the trade-tariffs endogeneity problem. A detailed explanation on the Reference Group Methodology is available in Bouët et al. (2008) and Guimbard et al. (2012). The weights based on the reference country groups allow for a better accountability of restrictive transaction costs. The reference period used to calculate the weights is the period 2018-2019, as in Guimbard et al. (2012). The weights are calculated as follows:

$$W_{p,i,j} = \frac{M_{p,i,R(j)} * M_{.,.,j}}{M_{.,.,R(j)} * M_{.,i,R(j)}}, \tag{C.1}$$

where $W_{p,i,j}$ is the weight used in the aggregation using product p exports from country i to country j. M refers to imports and $R(j)$ is the reference group of the importing country. The symbol "." refers to the total value. Therefore, $M_{.,.,j}$ are the total agri-food imports by country j.

$$tariff_{ijP} = \frac{\sum_{p=1}^{a1} t_{ijp} * W_{ijp}}{\sum_{p=1}^{a1} W_{ijp}} \quad \forall p = 1, ...a1, ...n, \tag{C.2}$$

Once we have computed the weights, we proceed with the calculation of weighted tariffs at the 4-digit level using WITS tariff data (t_{ijp}). We take the summation, where $a1$ refers to the set of products of the six-digit subheading within its corresponding four-digit group.

C.3 Robustness checks

Although the policies under evaluation are in response to the COVID-19 crisis and, theoretically, they should have an immediate impact on the markets, it is worth checking their delayed effect for robustness. The following results reproduce Tables 3.1, 3.2 and 3.4. For space reasons, gravity variables have been omitted when appropriate. Their coefficients held with previous estimates.

Table C.1: Effect of trade policy measures during the COVID-19 pandemic, one-month lag.

	(1) Cross-section (t=2020-03)	(2) Panel hs6	(3) Panel hs4	(4) Pair hs6	(5) Pair hs4	(6) OLS
log tariffs	-0.1696***	-0.1705***	-0.1075***	-0.1094***	-0.0237	-0.0760***
	(0.0309)	(0.0224)	(0.0281)	(0.0161)	(0.0183)	(0.0092)
Import facilitators	1.1516***	0.7962***	0.9591***	0.5919***	0.7838***	1.5897***
	(0.1120)	(0.0952)	(0.1670)	(0.0620)	(0.0885)	(0.0591)
Import restrictions	-0.5206***	-0.1805**	-0.5170***	-0.0649	-0.1979***	0.2213***
	(0.1163)	(0.0738)	(0.1275)	(0.0440)	(0.0724)	(0.0702)
Export restrictions	-0.5457***	-0.6105***	-0.0436	-0.2012***	0.0490	-0.1498
	(0.1284)	(0.1286)	(0.1377)	(0.0752)	(0.1063)	(0.1042)
Export facilitators	0.6945***	0.0086	0.2282	-0.2158***	0.0528	0.1621
	(0.2384)	(0.1283)	(0.1905)	(0.0800)	(0.1119)	(0.1594)
imp-exp RTA in place	0.1767***	0.2282***	0.3340***			
	(0.0650)	(0.0558)	(0.0553)			
Country-Pair FEs	no	no	no	yes	yes	yes
R-squared						0.6890
Pseudo R-squared	0.9105	0.9128	0.9320	0.9366	0.9595	
Number of observations	128,999	5,009,141	1,163,968	5,150,763	1,200,687	5,151,042

Note: Gravity estimation using monthly data. Columns (1) to (5) are reported using a PPML estimator. Gravity variables included but not reported. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table C.2: Effect of trade policy measures during the COVID-19 pandemic, three-month lags.

	(1) Cross-section (t=2020-03)	(2) Panel hs6	(3) Panel hs4	(4) Pair hs6	(5) Pair hs4	(6) OLS
log tariffs	-0.1676***	-0.1699***	-0.1073***	-0.1105***	-0.0228	-0.0771***
	(0.0317)	(0.0226)	(0.0285)	(0.0163)	(0.0185)	(0.0093)
Import facilitators	0.7278***	0.8479***	0.9437***	0.6187***	0.7640***	1.5807***
	(0.1984)	(0.0996)	(0.1686)	(0.0707)	(0.0880)	(0.0588)
Import restrictions	0.0289	-0.2585***	-0.5080***	-0.1147**	-0.1500**	0.2255***
	(0.1331)	(0.0778)	(0.1273)	(0.0472)	(0.0718)	(0.0685)
Export restrictions	-0.2399	-0.5491***	-0.0472	-0.1228	0.0644	-0.1414
	(0.1622)	(0.1256)	(0.1412)	(0.0777)	(0.1114)	(0.1077)
Export facilitators	-0.0448	-0.0511	0.3009	-0.2843***	0.1770	0.1302
	(0.2360)	(0.1348)	(0.1895)	(0.0785)	(0.1241)	(0.1561)
imp-exp RTA in place	0.1883***	0.2261***	0.3340***			
	(0.0678)	(0.0560)	(0.0557)			
Country-Pair FEs	no	no	no	yes	yes	yes
R-squared						0.6890
Pseudo R-squared	0.9122	0.9130	0.9317	0.9368	0.9594	
Number of observations	120,135	4,762,594	1,106,741	4,897,346	1,141,689	4,897,625

Note: Gravity estimation using monthly data. Columns (1) to (5) are reported using a PPML estimator. Gravity variables included but not reported. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

Table C.3: Effect of trade policy measures by food group, one-month lag.

	(1) Live Animals & Plants	(2) Meat & Dairy	(3) Cereals	(4) Fruits	(5) Vegetables
log tariffs	-0.0261	0.0327	-0.0803***	-0.0868***	-0.1058***
	(0.0515)	(0.0430)	(0.0308)	(0.0314)	(0.0336)
import facilitators	1.1517***	0.1829	0.5130***	0.5179***	0.6804***
	(0.2049)	(0.1348)	(0.0728)	(0.0626)	(0.0835)
import restrictions	0.3465*	-0.4343***	-0.1121	0.0297	0.1699*
	(0.1909)	(0.1231)	(0.0906)	(0.0817)	(0.0929)
export restrictions	1.0617*	0.0286	-0.4173**	-0.4660***	0.0516
	(0.5612)	(0.1441)	(0.1869)	(0.1463)	(0.1233)
export facilitators	0.0000	-0.4396*	-0.5554***	-0.7224***	0.3763*
	(.)	(0.2476)	(0.2047)	(0.2682)	(0.2021)
Country-Pair FEs	yes	yes	yes	yes	yes
Pseudo R-squared	0.9647	0.9561	0.9520	0.9523	0.9560
Number of observations	172,282	334,108	742,547	751,014	597,525

Note: Gravity estimation using monthly data. Columns reported using a PPML estimator. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Table C.4: Effect of trade policy measures by food group, three-month lag.

	(1) Live Animals & Plants	(2) Meat & Dairy	(3) Cereals	(4) Fruits	(5) Vegetables
log tariffs	-0.0240	0.0366	-0.0863***	-0.0866***	-0.1030***
	(0.0525)	(0.0438)	(0.0316)	(0.0316)	(0.0339)
import facilitators	1.1698***	0.1266	0.5419***	0.6191***	0.6543***
	(0.2044)	(0.1316)	(0.0752)	(0.0621)	(0.0894)
import restrictions	0.2234	-0.4872***	-0.1927*	-0.1025	0.1976**
	(0.2321)	(0.1283)	(0.0990)	(0.0800)	(0.0944)
export restrictions	0.9468*	0.0749	-0.3388*	-0.4734***	0.0869
	(0.5200)	(0.1430)	(0.1929)	(0.1450)	(0.1235)
export facilitators	0.0000	-0.4200	-0.5320***	-0.6708***	0.3110
	(.)	(0.2586)	(0.1709)	(0.2563)	(0.2030)
Country-Pair FEs	yes	yes	yes	yes	yes
Pseudo R-squared	0.9649	0.9564	0.9523	0.9523	0.9558
Number of observations	163,173	318,263	706,804	713,340	567,215

Note: Gravity estimation using monthly data. Columns reported using a PPML estimator. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

Table C.5: Effect of trade policy measures by cereal import dependency, one and three-month lags.

	(1)	(2)	(3)	(4)	(5)	(6)
	Net exporters		Countries IDR 0-50		Net importers	
	One-lag	Three-lag	One-lag	Three-lag	One-lag	Three-lag
log tariffs	-0.0231	-0.0253	-0.1576***	-0.1652***	-0.0439*	-0.0473**
	(0.0830)	(0.0845)	(0.0360)	(0.0361)	(0.0227)	(0.0229)
import facilitators	0.8642***	0.8915***	0.3328***	0.3912***	0.0972	0.3985***
	(0.1223)	(0.1143)	(0.0763)	(0.0821)	(0.1300)	(0.1176)
import restrictions	0.0585	0.0094	-0.2109*	-0.3036***	-0.1063	0.4681**
	(0.1491)	(0.1431)	(0.1132)	(0.1155)	(0.2520)	(0.2050)
export restrictions	0.7262***	0.7742***	-0.6986**	-0.4768	-0.8251***	-1.4050***
	(0.1455)	(0.1523)	(0.3104)	(0.3232)	(0.2591)	(0.2703)
export facilitators	-0.3780	-0.7457***	0.0364	-0.3383	-0.8477***	-0.0437
	(0.2948)	(0.2635)	(0.2624)	(0.2640)	(0.3218)	(0.1264)
Country-Pair FEs	yes	yes	yes	yes	yes	yes
Pseudo R-squared	0.9753	0.9754	0.9686	0.9690	0.9593	0.9595
Number of observations	218,325	207,586	241,992	230,579	213,887	203,711

Note: Gravity estimation using monthly data. Columns reported using a PPML estimator. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

The following results represent the regression following the model specification of Grant et al. (2021). The main difference compared to equation 1 is in the treatment of 3.1, as we now control for the quadruplet importer-exporter-product year. Country-specific fixed effects are now less stringent to allow for certain variability in the model, and they are only fixed at the country-year level. Standard errors are clustered by the importer-product-month triplet. The equation is defined as follows:

$$X_{ijctm} = exp[\beta_1 \ln \tau_{ijct} + \beta_2 MF_{ijctm} + \beta_3 MR_{ijctm} + \beta_4 XF_{ijctm} + \beta_5 XR_{ijctm} + \beta_6 Z_{ijtm} + \psi_{it} + \phi_{jt} + \kappa_{ct} + \theta_{mt} + \mu_{ijcm} + \epsilon_{ijctm}] \quad \text{(C.3)}$$

Table C.6: Regression in Table 3.1 following FE specification in Grant et al. (2021)

	(1) Cross-section (t=2020-03)	(2) Panel hs6	(3) Panel hs4	(4) Pair hs6	(5) Pair hs4	(6) OLS
log tariffs	-0.0612** (0.0253)	-0.0484*** (0.0061)	-0.0220** (0.0086)	0.0077* (0.0045)	-0.0032 (0.0070)	0.0112*** (0.0017)
Import facilitators	0.8102*** (0.1499)	0.6883*** (0.0521)	0.7630*** (0.0428)	0.1247*** (0.0283)	0.1249*** (0.0350)	-0.0268*** (0.0081)
Import restrictions	0.1329 (0.1890)	0.1865*** (0.0563)	0.4484*** (0.0955)	-0.0381 (0.0588)	-0.3009*** (0.0750)	-0.0749*** (0.0128)
Export restrictions	0.3339 (0.2342)	0.4038*** (0.1250)	-0.0530 (0.1022)	0.1087 (0.0840)	-0.2749*** (0.0599)	-0.0709*** (0.0258)
Export facilitators	-0.7981*** (0.2370)	-0.2323** (0.1177)	0.4587*** (0.1198)	-0.0332 (0.0638)	-0.0021 (0.0766)	0.0627* (0.0366)
Stringency index importer		-0.0008 (0.0007)	-0.0011 (0.0011)	-0.0005 (0.0003)	-0.0013* (0.0007)	-0.0006*** (0.0001)
Stringency index exporter		0.0003 (0.0007)	0.0003 (0.0010)	0.0003 (0.0003)	0.0010** (0.0004)	-0.0006*** (0.0001)
Country-Pair FEs	no	no	no	yes	yes	yes
R-squared						0.8723
Pseudo R-squared	0.5411	0.5415	0.5638	0.9707	0.9745	
Number of observations	151,248	6,036,510	1,500,369	5,047,541	1,121,840	5,048,002

Note: Gravity estimation using monthly data. Columns (1) to (5) are reported using a PPML estimator. Gravity variables included but not reported. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered by country-pair. *** p<0.01, ** p<0.05, * p<0.1.

We run equation 3.1 using quarterly data. Hence, our m dimension is replaced by q. Trade data flows are summed up every 3 months, while the rest of the variables remain unchanged. For the sake of clarification, trade policies are now equal to 1 if a trade intervention is currently in place between the pair of countries for commodity c at quarter q in year t.

Table C.7: Effect of trade policy measures during the COVID-19 pandemic, by quarter.

	(1) Cross-section (t=2020-03)	(2) Panel hs6	(3) Panel hs4	(4) Pair hs6	(5) Pair hs4	(6) OLS
log tariffs	-0.1054***	-0.0882***	-0.0821***	0.1012***	0.0828***	0.8037***
	(0.0318)	(0.0231)	(0.0208)	(0.0151)	(0.0148)	(0.0130)
Import facilitators	0.9222***	0.8839***	1.1559***	0.5566***	0.7845***	2.5241***
	(0.1545)	(0.0879)	(0.0992)	(0.0481)	(0.0517)	(0.1110)
Import restrictions	-0.2167*	-0.3048***	-0.2503***	0.0764	0.0559	1.3138***
	(0.1145)	(0.0902)	(0.0888)	(0.0540)	(0.0694)	(0.2513)
Export restrictions	-0.5093***	-0.4011***	-0.0291	0.0161	0.2055**	0.1455
	(0.1842)	(0.1201)	(0.1448)	(0.0729)	(0.0953)	(0.1395)
Export facilitators	-0.0853	0.3329**	-0.1565	0.0953	-0.1807**	1.8532***
	(0.2114)	(0.1525)	(0.1623)	(0.0850)	(0.0875)	(0.2409)
Country-Pair FEs	no	no	no	yes	yes	yes
R-squared						0.5410
Pseudo R-squared	0.9010	0.9018	0.8762	0.9324	0.9161	
Number of observations	379,816	5,123,528	3,056,352	5,249,254	3,132,551	5,735,696

Note: Gravity estimation using quarterly data. Columns (1) to (5) are reported using a PPML estimator, and column (6) is estimated with OLS. The dependent variable is bilateral trade flows in the agricultural sector at the 6 and 4-digit product level from country i to country j, X_{ijpt}. All estimates include importer-product-time and exporter-product-time fixed effects. Standard errors clustered at the country-pair level. *** p<0.01, ** p<0.05, * p<0.1.

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