Applied Economic Perspectives and Policy (2020) volume 00, number 00, pp. 1–31.
doi:10.1002/aepp.13124

Featured Article

Agricultural Trade Costs

John C. Beghin*, and Heidi Schweizer

Department of Agricultural Economics, University of Nebraska, Lincoln, NE
Department of Agricultural and Resource Economics, North Carolina State University, Raleigh, NC
Editor in Charge: Craig Gundersen
*Correspondence may be sent to: E-mail: beghin@unl.edu

Submitted 23 August 2020; editorial decision 27 October 2020.

Abstract *We examine the recent evolution of salient trade costs in agricultural and food markets, and changes in their composition. We review ways to measure costs and provide guidance with policy prescriptions to reduce them. We pay attention to transportation costs, border measures, and standard-like nontariff measures. By pointing out limitations in current approaches and recent developments, we aim to improve our understanding of their effects and derive clearer prescriptions. We suggest promising directions for further research and investigation of agricultural trade costs, including on the emerging debate on gene editing and trade, transportation costs, and mainstreaming recent advances in analyzing nontariff measures.*

Key words: Agricultural trade, Transportation, Tariffs, Nontariff measures, Policy prescriptions.

JEL codes: F14, Q17.

Trade in agricultural and food goods is special in the sense that moving agricultural goods across markets is costly (Hummels 2007) relative to farm-gate value. These goods tend to be bulky and/or perishable. They can affect human and plant health, broadly defined, if they do not meet quality standards. Policies addressing their safety create significant trade frictions and concerns among trading partners (Beghin 2017; WTO Committee on Sanitary and Phytosanitary Measures 2020). These trade costs,[1] expressed as a share of the total value of the shipped agricultural good, are high. This contrasts to the cost of shipping high-value manufacturing goods, such as a smartphone over the ocean (a few dollars in hundreds of dollars of the phone value landed in most OECD markets). In ad valorem form, agricultural trade costs are substantial. They have been on a secular decline, but with changes in their composition over time. Market access has improved with lower tariffs.

[1] *By trade cost, we mean that a border is present between parties producing, moving, exchanging, and consuming goods.*

However, nontariff measures (NTMs,) such as phytosanitary standards, have been rising sharply. Transportation cost has remained high.

This paper's contribution is to provide guidance on how to better measure and reduce these significant trade costs, with a focus on transportation cost and NTMs. We first set up a simple approach to characterize trade costs. Then the article reviews transportation costs (policies, freight, insurance), and price and quantity-based trade distortions (tariffs, TRQs, export restrictions) and standard-like measures (NTMs, nontariff barriers, and transparency measures). We review prescriptions to reduce each of these trade costs from economic theory and recent empirical findings. Following the sequence, we provide some directions for fruitful research on agricultural trade cost. Appendix S1 contains detailed data sources for the trade costs covered in the article.

The focus on transportation costs is notable. With a few exceptions (for example, Hummels 2007; Hummels, Lugovskyy, and Skiba 2009; Korinek and Sourdin 2010; Blonigen and Wilso 2018), applied trade economists have neglected the wealth of information available on trade costs associated with transportation. We provide this information for agricultural trade with the hope of raising awareness about these data and fruitful future use of them in either calibrated model simulations or econometric estimations. The contribution here is to bridge transportation economics and international trade. The focus on tariffs and associated policies is also timely with the current volatile trade policy environment. As a third notable element, we report on the major recent advances in understanding the economics of NTMs, which have been rising prominently in contrast to the secular decline in tariffs.

A Simple Approach

A Single Arbitrage Equation

To set the stage, we start with a simple approach, paralleling Calvin and Krissoff (1998), using a simple price transmission/arbitrage equation to express the law of one price between two locations (*A* and *B*) across a border. This equation can be integrated in a calibrated model for policy simulations or in an econometric specification to estimate trade flow determinants. We account for the exchange rate (*ER*) between the two currencies, per unit transportation costs (broadly defined) between the two locations (*TC*), price-based market-access impediments in both countries (*Tariffs*)[2], the cost of nontariff measures $t(NTM)$, cost of uncertainty (hedging and insurance for exchange rate, transportation, and other risk), corruption, and red tape cost in both countries, subsumed into an aggregate other trade cost (*OTC*).[3] We have:

$$p_B = ER*\left(p_A + TC_{AB}\right) + Tariffs_{AB} + t\left(NTM_B\right) + OTC_{AB}. \tag{1}$$

This simple approach is elaborated by incorporating imperfect substitution between the goods in origin (*m*) and destination (*x*) countries (Yue, Beghin, and Jensen 2006 and Liu and Yue 2013), with a simple and widely used CES

[2] *Border duties and other price based distortions can be expressed in ad valorem equivalent (in percent of the border price) or in specific form (in local currency units per physical unit added to the border price). Trade bans (import or export) have a tariff equivalent.*

[3] *We do not discuss in detail the trade costs associated with exchange rate, a vast topic in itself. See Auboin and Ruta (2013) for a review. These costs are relevant for agriculture, especially volatility of exchange rate.*

approach of the form $\underset{D,I}{Max}\ U(x,m,AOG) = (\alpha x^{\rho} + (1-\alpha)m^{\rho})^{1/\rho} + AOG$, with AOG being an aggregate all other good, and parameters α and ρ expressing preferences and the substitution between m and x ($\sigma = \frac{1}{1-\rho}$). This leads to the following price transmission between the source country (good m from A to B) and the close substitute in the destination country (good x in B) priced at price p_x:

$$p_x \frac{1-\alpha}{\alpha}\left(\frac{x}{m}\right)^{\frac{1}{\sigma}} = ER*(p_A + TC_{AB}) + Tariffs_{AB} + t(NTM_B) + OTC_{AB}. \qquad (2)$$

This approach allows us to derive trade and welfare implications, using the resulting demand and expenditure function from the CES structure in a consistent manner. One recovers the law of one price in (2) when σ goes to infinity and $\alpha = 1/2$. The CES structure also lends itself to the gravity framework used in many econometric investigations of trade costs and their impact on trade and welfare.[4] The price p_A itself could be affected by policies in B, say, some SPS requirements. Equations (1) and (2) can be amended to reflect these additional costs to export to destination B, and then p_A would reflect a general export price to any destination plus the additional cost to the specific destination B. Equation (2) could also reflect a shift in import and domestic demand x induced by a standard-like NTM affecting the willingness to pay for a better product (see the next section).

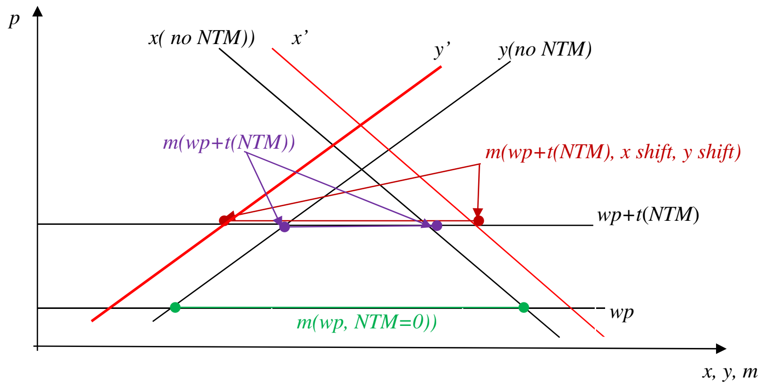
Note that this approach focuses on variable trade costs and does not address fixed costs or prohibitive cost, such as those involved in the extensive margin of trade with new products or new partners (Hejazi, Grant, and Peterson 2017; Scoppola, Raimondi, and Olper 2018).[5] An average fixed cost can be added to the average variable trade costs, and it is scale dependent (Scoppola, Raimondi, and Olper 2018). This addition is especially relevant for shipping cost as explained below and when thinking of the extensive margin of trade in new markets. Prohibitive trade costs can be accommodated econometrically applying the Kuhn-Tucker approach of Wales and Woodland (1983) to the corner solution (Yue and Beghin 2009).We briefly mention more elaborate approaches when needed.

Each component of these trade costs in equations (1) and (2) can incorporate a policy subcomponent. As we cover extensive ground already, we stay away from approaches using co-integration methods and thresholds to estimate "nonobservable" trade costs, which obfuscate arbitrage between markets (Goodwin and Piggott 2001; Lence, Moschini, and Santeramo 2018; and others). We also abstract from trade cost induced by distortions associated with domestic support via farm programs, although we cover export subsidies, which are sometime part of farm policy. We refer readers to the analyses of Smith, Glauber, and Goodwin (2018), Brink (2018), Brink and Orden (2020), and Orden (Forthcoming) to learn of distortive effects of these farm programs and compliance with WTO commitments to reduce these distortions.

[4] *The gravity equation framework posits that bilateral trade is increasing in the GDP of trade partners and decreasing in trade costs such as those associated with distance and other trade impediments. See Yotov et al. (2016) for its theoretical foundations chiefly based on a representative consumer with a CES utility function and output endowments leading to equilibrium bilateral trade flows in differentiated products.*

[5] *The extensive margin of trade refers to a trade expansion via new trade when either new firms enter a market or when a new product is introduced in an existing market. The intensive margin of trade refers to an expansion of already existing trade flows.*

Figure 1 The impact of a standard-like policy on supply, demand, price, and trade [Color figure can be viewed at wileyonlinelibrary.com]



The Economics of NTMs

The economics of standard-like NTMs have been extensively covered, notably by Josling, Roberts, and Orden (2004), and in earlier investigations (*e.g.*, see Bureau, Marette, and Schiavina 1998 and Tian 2003). Standard-like NTMs include technical barriers to trade (TBTs) and SPS regulations, as well as other "technical" NTM policies affecting the quality or the way goods are produced and marketed to final users. See the MAST classification for more details on these policies (UNCTAD 2019). These NTMs have common effects on markets, which allow economists to use common economic approaches to analyze them.

Broadly speaking, they affect the supply of a good by increasing its cost at the margin, by using extra resources to meet the standard or requirements of the policy. This often has a negative impact on domestic supply and competing imports in the sense of increasing their marginal cost, sometimes asymmetrically, depending on the relative ability of domestic and foreign suppliers to meet the standard. In addition, the standard may affect the demand for the good, as consumers may react to the standard if they know about it. For example, lower pesticide residue levels may induce consumers to consume more of a good. A warning label may deter consumers and shift demand to the left. These effects of standards are summarized for a small country case (with an exogenous world price, *wp* corresponding to a landed price p_A in equation (1)) for a homogenous good in figure 1. The figure is borrowed from Beghin, Disdier, and Marette (2015a).

In the figure, domestic supply y shifts to the left to y' once the policy NTM is in place. World supply also shifts up to reflect the additional cost of meeting the new standard. The new additive cost is expressed in a tariff equivalent, *t (NTM)*. The new world supply is now at *wp* + *t(NTM)*. In the same figure demand x is shown to have shifted to the right to x', presumably with a policy measure, which encourages consumers to consume more, say, because the product is now known to be safer or more nutritious. What is the trade cost effect of this NTM policy? The answer depends on what impact is being measured. The unambiguous impact on prices is a higher border price (from *wp* to *wp* + *t(NTM)*).[6] The impacts on trade and consumption are often ambiguous.

[6]*See Cadot, Gourdon, and Van Tongeren (2018) for a discussion of the increase in price induced by NTMs. One could come up with some extreme counterexample of a world price decreasing because of a new standard, but this is farfetched in most cases.*

Imports could increase because domestic supply has shifted to the left and because demand has shifted to the right. These two effects have to be compared to the impact of the higher price on imports. Similarly, the effect on net consumption may be ambiguous, comparing the price impact and the demand shift to the right.

This simple framework strongly suggests that inferring trade cost from the impact of the NTM on trade flows will be complicated if not erroneous, if the impact is not decomposed into a price effect and the respective impacts on domestic supply and demand. This problem has plagued many investigations of standard-like NTMs, which have found positive, negative, and insignificant effects on trade. Significant negative effects are often posited without rigorous justification or imposed on data from misguided intuition, using the analogy of tariff and border taxes.

Transportation Costs

It is well established that bilateral trade decreases as geographic distance increases, and distance is a common independent variable within gravity models. Distance is found to have a persistent negative effect on trade (Disdier and Head 2008). The approach is coarse, however. The circumstances where geographic distance is a good proxy for transportation costs (TC_{AB}) is less understood and not straightforward (see Bensassi et al. 2015 and Halaszovich and Kinra 2018). Their variation over time is also pivotal to understand their role. Many estimations actually exhibit the puzzling result of rising costs associated with distance over time (Yotov et al. 2016). Given knowledge of transportation systems, it is possible to be more precise about the transportation costs both captured and uncaptured by geographic distance—even when direct transportation cost data are unavailable.[7] The main components of transportation systems and costs are mode, infrastructure, technology, and policy, which are explained in sequence.

Transportation Mode

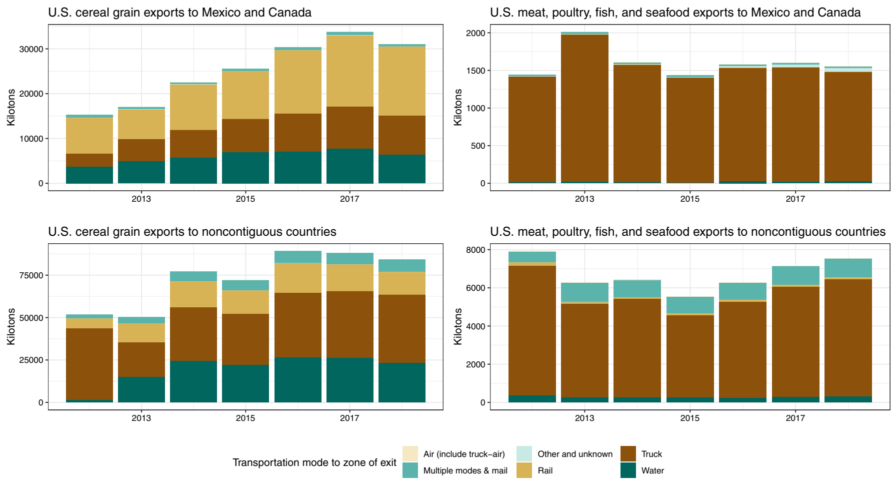
For measuring transportation costs, it is important to identify the transportation mode when more than one mode is probable. For example, ocean freight is the only relevant cost for shipping bulk grains from the United States to Europe or Asia (we need not consider air travel). Bulk shipping from the United States to Mexico or Canada may take place with any of the three primary modes (truck, rail, boat). Generally, economies of scale are captured with greater distances because the fixed cost of shipping via truck is less than rail, and shipping via rail is less than boat. Depending on data availability, mode choice is possible to assess though aggregate demand (modal split and behavioral) and disaggregate demand (behavioral and inventory) models.

Freight Analysis Framework data from 2012 to 2018 allows us to compare a bulk versus a perishable refrigerated commodity, and internal versus external transportation mode choices.[8] Figure 2 compares cereal grain and meat

[7] *Sources of direct transportation costs are listed in the appendix S1.*

[8] *The Freight Analysis Framework is a database that provides estimated historical flows and forecasted future flows of U.S. freight movements. Origin and destination, commodity, and transportation modes are specified. The primary data source is the Commodity Flow Survey, but agricultural movements are estimated using supplemental data (from USDA and Bureau of Census) since agricultural shipments are out-of-scope of the survey. See https://faf.ornl.gov/fafweb/.*

Figure 2 Cereal grain and meat internal movements to US exit zones by mode 2012–18. Data source: Freight Analysis Framework version 4. [Color figure can be viewed at wileyonlinelibrary.com]



transportation modes of US exports to exit zones, showing that rail and water transportation is more often used to transport cereal grains. Although the trucking may be more expensive than water or rail transportation of bulk commodities, trucking offers higher transportation service quality in terms of speed and reliability, which bears greater importance for meat. Also, the fact that meat needs to be refrigerated means that it is more difficult to capture economies of scale by switching to water or rail transportation where refrigerated cargo would still be handled in containers, or units not larger than a dry van, rather than bulk.[9]

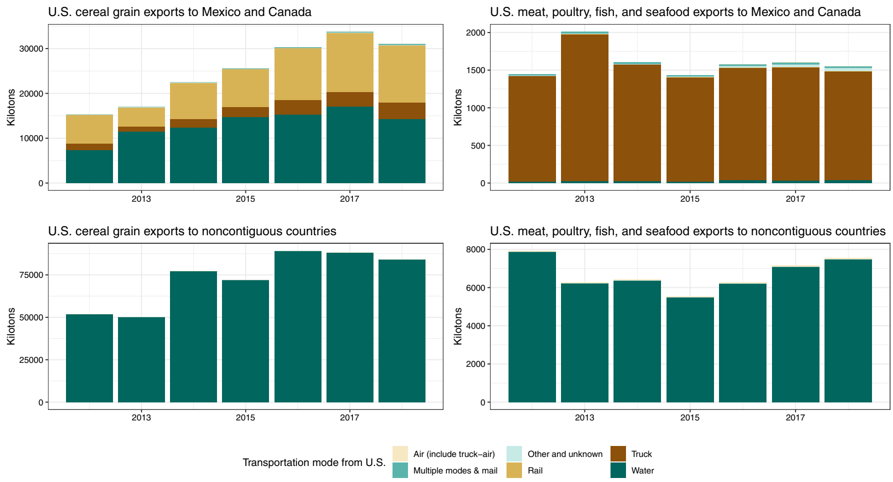
Figure 3 compares cereal grain and meat transportation modes of exports from the United States also using data from the Freight Analysis Framework. Both products destined for countries noncontiguous to the United States are almost always exported via boat.[10] However, most meat exports to Mexico and Canada are shipped via truck, while most cereal grains are exported to Mexico and Canada via water or rail. These graphs illustrate that (i) transportation mode shares for each good vary over time internally and externally, and (ii) transportation modes vary based on country pairs.

Gravity models provide the intuitive result that bilateral trade flows decrease when trade friction (specifically transport costs here) increases, however agricultural products have a variety of geographic, physical, and market characteristics that can lend themselves to distinctive transportation profiles. Whereas transportation demand is derived demand for an agricultural good, transportation supply consists of terminal costs, linehaul costs, and capital costs. Terminal costs include the handling at the origin, destination, and

[9]*Reefer ships with meat in breakbulk are now obsolete, in the modern era meat is containerized and refrigeration occurs at the level of the container. Reefer containers have their own cooling system but need access to the ship power supply. Insulated units do not have their own cooling system and must be plugged into the ship cooler system. This allows the environmental requirements to be different for each container depending on whether it needs to be frozen, chilled, or controlled (fruit). The shift away from reefer ships allows carriers to capture economies of scope by using the same vessels to move reefer, insulated, and dry containers.*

[10]*Low volumes of higher value meats (such as fish) can be shipped* via *air to ensure freshness.*

Figure 3 Cereal grain and meat movements from US exit zones by mode 2012–2018. Data source: Freight Analysis Framework version 4. [Color figure can be viewed at wileyonlinelibrary.com]



transloading. Linehaul costs include items such as fuel and equipment maintenance, and capital costs include equipment and infrastructure. These costs are heavily dependent on transportation mode choice; the measurements of transportation supply often address a single supply component for a specific mode. Measurements of physical capacity can include the number of lanes on a highway, which applies to linehaul costs, and the number of cranes at a port, which applies to terminal costs. Similarly, speed measurements apply to linehaul efficiency, while dwell time relates to terminal efficiency. Finally, there are inventories of capital stock in the road/rail/ocean freight networks. These measures can indicate congestion at a terminal or along a route, and transportation equipment availability.

The usual indirect and cross-sectional measures correlated with transportation costs included in gravity models are bilateral distance (continuous), adjacency (dummy), island (dummy), and landlocked (dummy). Some authors have also decomposed bilateral distance in its internal and international components (Yotov 2012). Each of these independent variables give insight to transportation mode choices and transportation cost. Islands are only accessible via water or air, landlocked countries are not accessible via water, and every transportation mode will require greater fuel to travel greater distance.[11]

We ideally hope to capture how additional distance or changes to transportation costs affect marginal trade flows as transportation profiles and transportation system performance vary. For example, the marginal change in flows between two countries due to increased fuel prices will differ based on the transportation profile of the commodity. Information about mode can be used to further accuracy, even in the absence of direct cost measurements. Data are often available for transportation mode, or reasonable assumptions can be made, for internal transportation mode of the exporting country, the transportation mode between countries, and the transportation mode of the importing country. Given that transportation costs vary over

[11] *A landlocked country may have access to a canal system, but the goods will still need to be transloaded onto a different type of vessel before it reaches the destination country.*

time and by mode, the information can be used to build a panel with transportation information that varies over time and by country pair. All this information can also be used for simulations with a calibrated model.

Infrastructure

Because infrastructure determines which inland modes are possible, as well as affecting both the fixed and marginal costs of each possible mode, the quality and quantity of infrastructure can significantly affect trade flows. Often, authors will use or create an index to quantify many facets of infrastructure. Commonly used indices are listed in appendix S1 and most include elements such as the number of distribution facilities, hub throughput and capacity, road/track density, as well as qualitative assessments from industry. Ultimately, these indices reflect the contribution of infrastructure on the supply of transportation services.

While infrastructure is a main component of transportation systems, infrastructure variables are not as conveniently incorporated into panel data analysis or calibrated models compared to other transportation data. First, due to the nature of infrastructure projects, there is often little variation year-to-year. Second, the indices readily available are not specific to the infrastructure facilities relevant to certain agricultural goods (for example bulk or cold chain). Third, specific to the context of trade, expanding transportation infrastructure and increasing trade flows often occur simultaneously, and the direction of causality is ambiguous. For example, Bensassi et al. (2015) show infrastructure increases Spanish exports while Nguyen and Tongzon (2010) find that growth in trade with China results in Australian transport sector growth.

Complicating analyses for agricultural goods is the fact that agriculture is seasonal, which results in peak-demand times for transportation services. Highly seasonal production strains storage, processing, and transportation facilities causing congestion when transportation demand exceeds transportation system capacity.[12] The pressure seasonality puts on infrastructure is difficult to capture on an annual basis, but could be used to weight annual transportation prices, or provide annual variation on infrastructure availability. Though it is usually more feasible to capture seasonality within a general equilibrium, partial equilibrium, or multimarket model, infrastructure can still provide important insights for agricultural goods if there exists information on the status of critical infrastructure or within-year flows.

Distortions/Policy

As with the previous components of transportation systems, policies that distort transport costs can be applied at the origin region, along a route between an origin and destination, and in a destination region. Origin (or destination) specific policies may affect internal transportation costs, external transportation costs, or both. External transportation costs may also be affected by trade and environmental agreements.

Examples of US policies that distort internal transport costs—through all three types of transport cost—include the Foreign Dredge Act of 1906 and the USDOT electronic logging device mandate that went into effect in 2017. The Foreign Dredge Act of 1906 prohibits foreign dredgers from dredging

[12] *Likewise, supply disruptions can cause congestion, such as Mississippi River flooding halting barge traffic.*

in the United States. Rivers and ports require dredging for both maintenance and improvements, and reduced competition among dredging firms ultimately increases the costs of waterway and port infrastructure. Navigation restrictions due to foregone waterway improvements result in excess freight traveling via more expensive modes. Compare this type of policy to the electronic logging device mandate which requires nearly all commercial trucks to have electronic devices recording hours-of-service in addition to other data.[13] Although this policy was not a change in hours-of-service rules per se, it was a large change in the enforcement of these rules. With electronic logs, drivers have less flexibility over how their dwell time at terminals is recorded, increasing terminal costs. Despite the divergent nature of these policies, they both result in mode-specific changes to internal transportation costs.

Along with the Foreign Dredge Act of 1906, the 1920 Merchant Marine Act (also known as the Jones Act) is an example of national policy that increases external costs. The main segments of the 1920 Merchant Marine Act specify that goods shipped between US ports must be shipped on vessels that are US built, US flagged, owned by a company that is at least 75% US owned, and crewed by a minimum of 75% US sailors. This policy applies specifically to domestic shipments, but limits options to reposition containers used in international trade.[14] Without a feeder-ship market, containers are shuffled on land resulting in more expensive terminal costs (Bain and Company and the World Bank 2013; Smith, Glauber, and Goodwin 2018 and Frittelli 2019).

Finally, the International Maritime Organization (IMO) changed external trade costs for nearly all maritime trade partners with new emissions regulations effective January 2020. The regulation prohibits vessels from using high-sulfur fuel oil. The main shipowner compliance options are to switch to marine gasoil or liquefied natural gas, install scrubbers, or scrap the vessel. More expensive fuel directly increases linehaul costs, while converting engines to use alternative fuels and installing scrubbers increase the costs of capital stock. This policy is likely to affect segments of maritime markets differently depending on fleet composition, the possibilities for alternative routes, and the degree to which member states enforce the regulation (Halff, Younes, and Boersma 2019).

In general, transportation-specific policy will vary most by country rather than over time. As demonstrated in the examples provided in this subsection, the policies for an importer or exporter can have a direct effect on any of the three main types of transportation costs for both internal and external trade costs. Also note that these distortions will influence behavior within transportation *systems*.

Technology

Technology improvements take many forms and may reduce any cost component mentioned in the previous section on transportation mode—however, some developments in technology have the potential to reduce several cost components at once. For example, the most notable innovations in marine shipping technology are steamships in the 19th century, followed by containerization in the 1950s. Steamships primarily reduced linehaul costs, while containers reduced capital costs and terminal costs, while allowing carriers

[13] *There are some exemptions to hours-of-service rules for agriculture. https://www.fmcsa.dot.gov/hours-service/elds/eld-hours-service-hos-and-agriculture-exemptions*

[14] *There is an exemption for empty containers.*

to capture economies of scope by offering refrigerated and nonrefrigerated service on the same vessel. Both technologies led to increased global trade volumes, and containerization specifically increased US exports of perishable products (Coyle, Hall, and Ballenger 2001).

Technologies that address multiple cost components underscore the system aspect of transportation by allowing for holistic views of transportation movements (and supply chains more broadly). Both private industry and policymakers are placing increased scrutiny on agricultural supply chains following the 2020 coronavirus pandemic and in expectation of increased frequency of extreme weather events.[15] When transportation systems fail to meet demand for an extended period of time, these are defining moments—and these moments are partly responsible for the widespread movement away from just-in-time inventory and supply chain management strategies towards strategies with more robustness and resilience (Behzadi et al. 2018).

Although new technology for transportation equipment is quickly advancing, the innovations that have the greatest promise for reducing costs related to transportation are being made in the inventory and supply chain management spaces. Often overlooked by those outside the industry, freight forwarding firms play an important role in reducing bureaucratic and price discovery costs in transportation markets. Freight forwarders are experts in the complete process of moving freight from an origin to a destination. They manage negotiation of rates, payment, customs paperwork, insurance, and delays. There can be specialization by region, transportation mode, and type of good.[16] The proliferation of tracking and management technologies being applied to improve supply chains provide firms in transportation and these adjacent spaces opportunities to improve their service quality. Examples of these technologies include distributed ledgers and remote sensors, which can speed up customs paperwork, verify environmental conditions throughout the journey, and facilitate cross-border contract enforcement.

Measures related to institutions and corruption, such as those available from the World Bank or Transparency International (see appendix S1 for these data sources), relate to bureaucratic costs that occur during transportation and handling that tracking and sensor technologies are targeted towards reducing. Although faster and more reliable border processing can benefit any type of good, perishable products especially benefit from reduced spoilage. Time delays as measured by requirements to export and imports in Doing Business (World Bank) have been shown to reduce trade flows of perishable agricultural goods (Liu and Yue 2013). We expect that implementation of technologies especially relevant to time delays in agricultural trade will improve these estimated effects. In addition to direct measures of

[15]*Most public scrutiny of the food supply chain due to disruptions caused by the 2020 coronavirus pandemic have focused on domestic processing and distribution of high-value products such as meat and produce. It is unclear if, and to what degree, transportation of bulk agricultural commodities was affected. For grains and oilseeds, the onset of the pandemic and corresponding shutdowns in the United States occurred during spring, when there tend to be lower levels of transportation demand. There was also a simultaneous leftward shift in export demand (from which transportation demand is derived) due to the ongoing US-China trade war and the outbreak of African Swine Fever.*

[16]*Freight Forwarders will often accept and organize less-than-truckload shipments not accepted by major carriers. However, this is not the case for perishable products as opportunities are infrequent. These firms are not to be confused with brokers, because forwarders often do handle freight in their warehouse facilities. They are also not to be confused with carriers, because they typically do not own transport equipment. There is some overlap between freight forwarders and third-party logistics providers (3PLs) who will also handle supply chain tasks, such as inventory management, in addition to shipping.*

technology, measures of institutional quality and importer/exporter dummies can control for some of the variation in transportation technology.[17]

The Reduction of Agricultural Tariffs and Associated Border Distortions

In contrast to agriculture, manufacturing trade has been extensively liberalized in the last 70 years through multiple General Agreement on Tariffs and Trade (GATT) WTO rounds of multilateral negotiations and regional agreements. Agricultural policy and trade distortions were majorly addressed in the WTO's Uruguay Round Agreement on Agriculture (URAA) starting in 1995. A few piecemeal agricultural policy changes came through the GATT before the URAA, but the URAA was the first comprehensive approach to address the many distortions present in these markets. The uncompleted Doha Round has been essentially stuck with no conclusion in sight. Little progress has been made in a multilateral fashion after the implementation period of the URAA, which ended in 2005.

Regional and bilateral trade agreements have significantly substituted for the lack of progress in multilateral liberalization and have provided a patchwork of unevenly lower tariffs, with some TRQs and the usual few remaining bastions of high protection in dairy, sugar, and cotton fiber. TRQs exist under regional and bilateral agreements, providing restricted access to particular US trade partners like Australia and Dominican Republic-Central America Free Trade Agreement (CAFTA-DR) members, among others, and restricting access to other countries. Trade diversion remains.[18]

In contrast to this secular trend, since 2017, substantial trade policy disruptions have taken place creating substantial trade costs, using aggressive unilateralism, primarily in the United States. Predictably, the unilateralist policies have been followed by retaliations from trade partners targeted by these measures. Manufacturing sectors were targeted by the United States, but retaliatory tariffs hit US agriculture substantially. Similarly, the temperamental renegotiation of NAFTA and hasty withdrawal from the Trans Pacific Partnership (TTP) agreement have had a disruptive effect on complex supply and value chains in agriculture and food markets (Bellora and Fontagné 2019). The disruptions could lead to hysteresis from trade costs, with permanent loss of some foreign markets, as explained later.[19] The United States has become a less dependable trade partner with new uncertainty-related costs for our trade partners. The topic of agricultural trade costs is timely.

Tariffs

Tariffs are a brunt and untargeted policy instrument in the sense that they jointly affect production and consumption decisions. Tariffs have historically

[17]*Other variables that may control for some portion of transportation technology are largely context-dependent, for an example, see Pascali (2017).*

[18]*Trade diversion refers to trade flows diverted from the lowest-cost exporters to less competitive exporters favored by the enhanced market access created by a trade agreement or in a custom union with an external tariff. The efficiency loss potentially reduces welfare (Viner 1950). See Magee (2008) for a review of the literature addressing trade diversion. See also Mattoo, Mulabdic, and Ruta (2017) for a recent empirical assessment of these potential effects with RTAs.*

[19]*Hysteresis is a situation where the economic consequence of an economic shock or change persists after the shock or change has been removed, such as a recession shock and post-recession persisting unemployment or exchange rate shocks and entry and exit in markets (Dixit 1989 and Summers 2014).*

been a major source of trade costs (Anderson and van Wincoop 2004). Tariff reduction has been a robust policy recommendation to increase trade and improve welfare, both on theoretical and empirical grounds. For example, early work by Hatta (1977) and others paved the way to a large theoretical literature identifying sufficient conditions for welfare-improving piecemeal reforms involving tariffs alone and tariffs with other distortions including those affecting agricultural trade (Hatta 1977; Falvey 1988; Anderson and Neary 1992; Beghin and Karp 1992 and Neary 2007). Empirical exercises have also established the welfare gains and distributional consequences of tariff reductions in agriculture and other sectors (Goldin and Van Mensbrugghe 1995; van der Mensbrugghe and Beghin 2004 and Anderson, Martin, and Van Mensbrugghe 2006).

Agricultural tariff structure is complicated and highly heterogeneous across goods and countries. Tariffs can be specific (x dollars per physical unit) or ad valorem (in percent of unit price p_A) or both combined. In addition, WTO member countries commit to tariff bindings (not to be exceeded) within the WTO. These are called Most Favored Nations (MFN) bound tariffs. They then define MFN applied tariffs, which can be applied to transactions with other member countries, or with countries having MFN status without being a WTO member (e.g., China before its WTO membership received MFN status in the United States, renewable yearly).

Further, MFN applied tariffs are often superseded by preferential tariffs established in regional trade agreements (RTAs), such as the US-Mexico-Canada (USMCA) agreement. These RTAs often have their own bindings and applied rates. Many RTAs have reciprocal zero tariffs on many trade flows. Frequently, tariff concessions are subject to rules of origin to preserve the trade diversion created by the RTA, which benefits producers within the RTA and hurt consumers/users in the RTA through higher prices than would prevail with global free trade. This trade diversion hurts exporters outside of the RTAs. Trade diversion has decreased given the multiplicity of deep-integration[20] RTAs (Mattoo, Mulabdic, and Ruta 2017) and the resulting lowering of tariffs in most countries. Diversion still persists along supply chains (see, for example, Conconi et al. (2018) for the case of NAFTA).

Despite the complex and heterogeneous structure, tariffs on agricultural trade are now low on average compared to pre-1995 levels. However, they remain higher than those on manufacturing goods. To illustrate, the United States has bound MFN tariffs averaging 4.9% (ad valorem equivalent) in agriculture (simple average), and 3.2% in manufacturing. Applied MFN tariffs are 3.9% on average in agriculture (trade weighted average in 2017), and 2.2% in nonagricultural sectors. To provide perspective, Gibson et al. (2001) estimated that in 2000, US agricultural tariffs were around 12%. Bureau, Guimbard, and Jean (2019) also show the substantial global decrease in agricultural tariffs from 2001 to 2013.

The distribution of agricultural tariffs indicates that roughly 39% of US agricultural imports enter duty-free, 40.5% enter at rates between 0 and 5%, and 13.5% enter at rates between 5 and 10%. Table 1 shows these bound and applied MFN tariffs by sector for the United States, dairy products, sugar

[20]*Deep integration refers to the comprehensive integration of markets beyond market access provided by lowered tariffs and expanded quotas. It covers NTMs (SPS and TBT measures), services, investments, labor, transparency requirements, intermediation, and other regulatory aspects of markets towards coordinated policies.*

Table 1 U.S. tariffs and imports by product (from WTO online)

	Final bound duties				MFN applied duties			Imports	
Product groups	**AVG**	**Duty-Free in %**	**Max**	**Binding in %**	**AVG**	**Duty-Free in %**	**Max**	**Share in %**	**Duty-Free in %**
Animal products	2.4	30.8	26	100	2.3	30.8	26	0.5	26.4
Dairy products	19.2	0.3	127	100	19.6	0.3	127	0.1	12.9
Fruits and vegetables, plants	5.0	20.2	132	100	4.7	20.9	132	1.6	24.6
Coffee, tea	3.0	53.5	23	100	3.0	53.5	23	0.5	74.4
Cereals & preparations	3.6	21.0	47	100	3.1	20.1	47	0.7	35.7
Oilseeds, fats, & oils	4.5	23.9	164	100	7.3	25.9	164	0.4	34.0
Sugars and confectionary	13.1	2.9	67	100	14.5	2.7	57	0.2	5.9
Beverages & tobacco	15.1	27.7	350	100	18.4	25.1	350	1.2	49.3
Cotton	5.0	38.3	19	100	5.0	38.3	19	0.0	78.5
Other agricultural products	1.2	58.9	51	100	1.1	61.0	51	0.4	66.5

and confectionery, and beverage & tobacco remain protected, with limited imports entering duty free. Tariff data are available for most countries (see appendix S1).

Tariff Rate Quotas (TRQs)

To further complicate matters, several of these imports, often deemed "sensitive products" are regulated with tariff-rate quotas (TRQs), a two-tier tariff scheme. To increase market access, the WTO created TRQs to replace quotas by structuring a low tariff (in-quota tariff) for imports up to the existing or former quota and a much higher tariff (out-of-quota tariff) for imports above the quota (Moschini 1991 and Boughner, de Gorter, and Sheldon 2000). TRQs continue to create inefficiencies as former quotas did. The hope was that in subsequent WTO negotiations, two-tier tariffs could be reduced, and quotas expanded. This has not taken place, although quota allocations have expanded through RTAs and preferential trade agreements (PTAs).[21] The administration of TRQs has been a recurrent issue in some countries (Boughner, de Gorter, and Sheldon 2000; Chen, Villoria, and Xia 2020; and Orden forthcoming), but not all (e.g., see Barichello (2000) on Canadian dairy TRQs). TRQs remain unfilled because rights to exports were allocated to uncompetitive exporters. Rights to import are often allocated inefficiently when there is no mechanism to reallocate the rights when they are not used, leading to quota underfill. In some cases, protectionism is the motive to systematic underfill of the quota, such as found in the US-China dispute (DS517) on Chinese TRQ management for grains (Orden forthcoming).

In their simplest form, TRQs introduce a discontinuity in equations (1) and (2) with the tariff change once the quota is filled (Moschini 1991 and Boughner, de Gorter, and Sheldon 2000). Out-of-quota tariffs are often prohibitive. This possibility complicates the computation of the trade cost element of the TRQs, since the out of quota tariff will overstate the cost of the price-equivalent effect of the TRQ when it is binding. In addition, quality upgrades can occur when exporters face managed trade or when shipping cost per unit is fixed, reducing the relative price of the higher-quality good (Ramos, Bureau, and Salvatici 2007). These reasons can lead to "shipping the good apple" out (Hummels and Skiba 2004 and Ramos, Bureau, and Salvatici 2007). TRQ data are widely available from the WTO and other sources.

Regional and Preferential Trade Agreements

The key reason agricultural tariffs have fallen globally reside in RTAs and PTAs (Korinek and Melatos 2009). For example, when looking at trade with RTA partners, the United States has much lower tariffs on its imports than the MFN applied tariff rates suggest. Specifically, most agricultural imports coming from Canada and Mexico enter duty-free (92.3% of agricultural tariffs lines for Canadian exports and 97.5% of tariff lines for Mexican agricultural exports), representing 99% of agricultural trade value with these countries (WTO 2019). Here again, a few agricultural trade flows within the USMCA are restricted by TRQs (e.g., Canada dairy imports) and managed trade (sugar flow from Mexico to the US). Despite these exceptions, agricultural trade

[21]PTAs provide concessionary market access to some trade partners without the expectation of reciprocal preferential access into the partners' market. PTAs are often provided to developing countries to facilitate export growth and promote development.

flows have been greatly and globally liberalized with RTAs, such as the USMCA and continue to be with new agreements such as the Comprehensive and Progressive Trans Pacific Partnership (CPTPP).

Beyond tariff schedules, countries use additional duties (safeguards, antidumping, and countervailing duties (CVDs)) in some special situations involving some injury or disruption test.[22] The latter can be subject to political pressure, as it was the case for rising sugar imports from Mexico to the United States in 2013–14, leading to US antidumping and countervailing duties on Mexican sugar coming into the United States. These duties were later suspended in favor of a managed trade regime capping Mexican exports to the US market (Beghin and Elobeid 2017). The reliance on safeguards and CVDs has not led to major trade impediments. To illustrate, from 1995 to end of 2019, 185 safeguard measures have been notified to the WTO [see WTO (2020a)] on safeguard measures). When compared to other policy notifications, this number is small. India, Indonesia, and Turkey are the largest initiators of safeguards. Eighteen dispute cases have mentioned safeguards in agriculture and food markets. A single contentious safeguard often leads to multiple dispute cases by different WTO members.

Many OECD and other advanced economies have been entering a series of RTAs since the early 1990s, at a steady pace (see WTO Regional Trade Agreements Database). In addition, the coalitions of members in some of these RTAs have become large (e.g., 11 countries in the CPTPP, various EU-27 agreements with other countries).

Tariffs have also decreased through unilateral decreases, outside of agreements as documented by Bureau, Guimbard, and Jean (2019). Finally, tariffs have fallen via various PTAs, which provide nonreciprocal tariff concessions, many of them to least developed or developing countries. These PTAs have increased market access in many OECD countries. Rules of origin constrain these concessions, however. Major agricultural tariff concessions have been made with PTAs as illustrated in Table 4.2 for the United States, with many tariff lines being tariff-free, under Generalized System of Preferences (GSP)[23] and the African Growth Opportunity Act (AGOA) (Tadesse and Fayissa 2008 and Williams 2015). The EU made comparable concessions under the Everything but Arms Initiative (EBA) (Brenton 2003).

These tariff concessions have had a more limited impact on agricultural exports of less developed countries (LDCs), because of rules of origin, TRQ exclusions, SPS requirements, and other supply chain constraints in countries eligible for the tariff concessions. To illustrate these tariff patterns, in 2018 the United States imported about $128 billion of agricultural goods, of which 39% entered MFN duty free; $20 billion came from countries beneficiaries of GSP extended by the United States, 80% of which entered under PTA or RTA benefits; agricultural imports from LDC-beneficiaries amounted to $1 billion, 80% of which entered under PTA or RTA benefits (WTO PTA database). Over time, tariff preferences under PTAs have eroded relative to prevailing tariffs outside of the PTAs, because countries entered RTAs or gained market access under MFN tariff concessions under the URAA (Bouët et al. 2005; Bureau,

[22] *Antidumping duties apply at the firm-level to offset the dumping margin (the extent of selling below cost) by that foreign firm. CVDs apply at the country level and are determined to offset the subsidy received by the industry in that country to "level the playing field" with domestic firms.*

[23] *The GSP provides duty-free treatment to goods of designated beneficiary developing countries to promote economic growth. It was created under the 1974 US Trade act.*

Jean, and Matthews 2006). An important element of most RTAs and PTAs is the expectation and commitment to transparency. WTO members provide sufficient information on the various concessions they make on tariffs, the associated rules of origins, NTMs, such that trade partners can take advantage of these concessions. Transparency is addressed more in depth in the section on NTMs.

With these two trends (larger and more numerous RTAs), agricultural tariffs have continued to fall globally, despite the lack of progress in the Doha Round of negotiations of the WTO for further agricultural tariff cuts, and despite the trade policy departures initiated by the Trump administration and the resulting higher tariffs facing US commodity exports.

The Trade Integration Hiatus

The US departures in trade policies include exiting the Trans Pacific Partnership agreement (TPP) in early 2017, raising tariffs on trade partners in a return to "aggressive unilateralism" (Kherallah and Beghin 1998), not seen since the Reagan era, in the last three years (Elliott and Richardson 1997; Elliott and Bayard 1994; Fajgelbaum et al. 2020; and Orden forthcoming). The hiatus also includes stalling the Transatlantic Trade and Investment Partnership (TTIP) negotiations with the EU, and making the WTO dispute settlement and appeal processes nearly inoperable (Orden forthcoming; Bown and Irwin 2019). The latter was undertaken by blocking the appointment of judges of the WTO Appellate Body.[24]

As reported by Elliott and Bayard (1994) and Elliott and Richardson (1997), unilateralism in the 1980s rarely led to trade wars and was moderately successful at gaining market access. In contrast, the trade wars with China and other partners on metallic and other products have been bruising for US agricultural commodities (and other sectors), with no end in sight. Mattoo and Staiger (2020) characterize this trade policy regime as a shift from a rule-based to a power-based system, using leverage by creating large imports but at the cost of undermining the global rule-based trading system.

The Phase One US-China agreement is a managed-trade agreement which is fundamentally trade distorting (Feenstra and Hong 2020). In addition its unmet agricultural export targets are new realities (Balistreri et al. 2018; Chepeliev, Tyner, and van der Mensbrugghe 2018; and Orden forthcoming). Many retaliatory agricultural tariffs remain in place and market access has not improved significantly, especially under the disruption brought by the global pandemic.

In addition, Mexico was pressured by the Trump administration to renegotiate NAFTA with threats of tariffs being reimposed on its trade flows as late as June 2019. The negotiation has taken place in the context of Mexico having 14 FTA/RTAs in place with 50 countries including the EU-27 and EFTA countries, the 2018 11-member CPTPP, and the upgraded USMCA (Villareal 2017; WTORTA 2020). In the last two decades, Mexico has signed a series of RTAs with Central and Latin American countries to integrate into the Americas beyond the USMCA. An implicit objective has been to diversify its export prospects and decrease its dependence on the US market for its exports. The actual gains to US agriculture and economy from the USMCA are modest

[24] The United States has been frustrated by the Appellate Body's slow dispute process and its judicial overreach. It has sought reforms unsuccessfully and has blocked the nomination of appellate judges as a way to create leverage.

(Chepeliev, Tyner, and van der Mensbrugghe 2018) relative to the original NAFTA.

Finally, the Trump administration's early decision to not ratify and leave the TPP agreement was a major blunder, which has penalized US agricultural exports through trade diversion (Bown and Irwin 2019). The remaining 11 TPP partners concluded the CPTPP, which provides preferential market access to its members. US exports are penalized by tariff differentials in these countries unless an agreement exists with that country. For example, Australian beef gets into Japan at a lower tariff rate than US beef does. The United States has agreements with Canada, Mexico, and Japan, which mitigate the trade diversion. Nevertheless, a major opportunity has been lost.

Export Distortions, and Bans

Agricultural export distortions were much restricted under the URAA and eventually eliminated through a multilateral agreement in 2015 (Orden forthcoming). The EU removed most of its agricultural export subsidies with its EU Common-Agricultural-Policy reforms, which became unsustainable under the EBA initiative and commitments under the WTO. Implicit export subsidies remained an issue through other components of farm policies distorting world trade. For example, the former US cotton program, which led to the long US-Brazil dispute at the WTO (DS 267), provided implicit export subsidies and distorted world cotton prices. The current US cotton program is potentially as distortive as the older one, with a negative effect on world prices (Smith and Glauber 2019). Fortunately, this type of egregious case is uncommon.

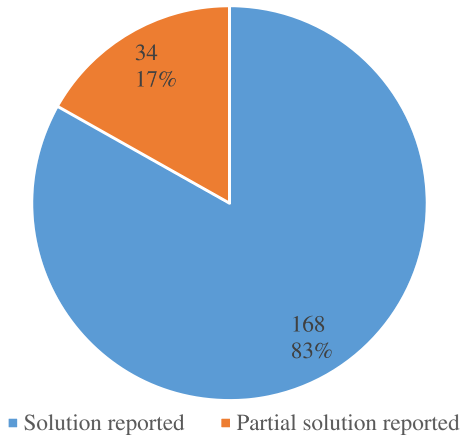
The topic of export distortions has re-emerged in the ramping up of world prices in 2005–10 but with a twist. Export restrictions were the new issue rather than subsidies. Countries with large grain production, especially rice, imposed export restrictions attempting to secure cheaper domestic supplies. These restrictions actually exacerbated the original price increases (Martin and Anderson 2012) and induced further price volatility and uncertainty by lack of collective action. With the 2020 global coronavirus pandemic, worries were voiced again that some countries might reiterate with grain export restrictions (Martin and Glauber 2020; OECD 2020 and WTO 2020b), although so far these trade impediments have been limited. Ample world supplies temper the concerns of price increases.

Nontariff Measures (NTMs)

Trade Costs Related to Standard-like NTMs and their Proliferation

Standard-like NTMs have proliferated in the last 25 years as suggested by annual reports of the SPS and TBT committees of the WTO. For example, more than 26,000 SPS notifications have taken place at the WTO since 1995 (SPSIMS WTO website). An even larger amount of TBT notifications has taken place (see WTO IMS website). Perishable agricultural products tend to be subject to more regulations and standards (Disdier and van Tongeren 2010 and Grant and Arita 2017). These measures have created trade frictions, as explained in the simple approach section, because they raise the cost of production for all suppliers and may restrict trade despite enhancing demand. The proliferation has induced concerns among trading partners, many officially reported at the WTO. For example, 469 SPS-specific trade

Figure 4 WTO SPS concerns from 1995–2019 and their resolution (source: WTO 2020). [Color figure can be viewed at wileyonlinelibrary.com]



concerns have been logged with the WTO SPS Committee (as of July 2020) and 49 formal disputes have been initiated citing the SPS agreement, leading to 19 fully developed cases. Similarly, official concerns and disputes have been caused by TBTs, many of them affecting trade of agricultural products. Hence, at face value, standard-like measures have been a major source of trade costs.

Many of these concerns have remained unresolved. See figure 4, and Grant and Arita (2017) for a detailed analysis of SPS concerns up to 2017. Specifically, out of the aforementioned 469 SPS concerns, 267 of them remain unresolved. Only 168 (36%) of them were fully resolved, and 34 were partially resolved. Similarly, the Dispute Settlement mechanism at the WTO offers a slow resolution to disputes, especially on SPS matters. Disputes are long enough to cripple any foreign firm with unfair practices for years. Even when disputes reach a conclusion, the condemned practice may remain in place at a small price corresponding to the economic loss of negotiated market access. To illustrate, the US-EU dispute on growth hormone took 13 years to be resolved and the EU market is still closed to US beef, which comes from animals having received growth hormones. The EU is willing to face US duties on selected products for not opening its market, and it has allowed some hormone-free US beef to enter the EU.

Frictions and disputes on SPS and TBT measures related to food also reflect cultural differences with respect to food, beyond protectionist motives (Sheldon, 2002). Josling (1999), and Heumueller and Josling (2004) have offered a lucid disambiguation of these two motives as they looked at food labelling requirements for GMO-free products. They explain how to consider ethical considerations such as the desire to eat GM-free food and the right to avoid deceptive practice. Simultaneously, protectionism can be minimized by requiring evidence of consumer preferences for a label or characteristic.

Despite these NTM frictions, agricultural trade has expanded vastly during the same period, as noted earlier. Hence, the frictions have not constituted prohibitive barriers, except for outright import bans, many of them during epizootic episodes. Back-of-the-envelope estimates by Grant and Arita (2017) suggest that SPS concerns have had large negative effects. However, more formal analysis would be enlightening. Transparency requirements and periodic consultations in many trade agreements have helped to contain trade costs associated with SPS concerns, as we explain below. Most empirical investigations of NTMs have focused on the net trade impact without decomposing the separate impact on supply, demand, and price as explained in the approach section. Not surprisingly, findings are muddled with findings of trade impeding and enhancing effects, as well as insignificant effects. For details on these various estimated effects and patterns, see the meta-analyses of Li and Beghin (2012), and Santeramo and Lamonaca (2019), and the review of Beghin, Maertens, and Swinnen (2015b).

Potential Protectionism of NTMs and Policy Prescriptions

Many NTMs can be protectionist, guided by rent-seeking rather than allocative efficiency (see Hillman (1989) for an example of such a case). The UNCTAD MAST taxonomy and NTM database provide an extensive list of NTM distortions, other than technical NTMs (the standard-like measures discussed here) (de Melo and Nicita 2018 and UNCTAD 2019). Figure 1 suggests that market imperfections, such as externalities and asymmetric information can be remedied by standard-like NTMs (e.g., the shift of demand reacting to information). In general, one needs a more complex framework to address the market imperfection (see Disdier and Marette 2010; Van Tongeren, Beghin, and Marette 2009; and Wilson and Antón 2006 for partial equilibrium approaches; and Beghin, Disdier, and Marette 2015a for an economy-wide approach).

Beyond getting rid of protectionist standard-like NTMs, international trade theory does not provide guidance on welfare improving policy reforms. This is unlike for taxes and tariffs. Establishing protectionism takes place at two levels: one easy and one more complex. The easy tests of protectionism deal with the violation of basic tenets of WTO agreements (Hooker and Caswell 1999). Standards have to be based on a risk assessment and proper science, or address potential informational asymmetries (Wilson and Antón 2006 and Grant and Arita 2017); they have to meet domestic treatment (no discrimination between domestic and imported of like-products). Precautionary measures cannot last without establishing the science; and all measures should be least-trade restrictive for a given correction level of a market imperfection (see Marette (2016) for the analysis of the choice of instruments).

The WTO also encourages but does not require use of international standards, such as those established by CODEX Alimentarius. As countries face specific conditions, a standard could deviate from international ones without being presumably protectionist. However, systematic deviations from international norms to impose more stringency than that implied by international standards should be met with skepticism. Li and Beghin (2014) provide such investigation on pesticides and veterinary drug residues. They show that the EU, Taiwan, Australia, and Turkey systematically exceed the stringency of CODEX when they set their standards. Beyond the issue of level of the NTM policy instrument, the enforcement of these policies could also be protectionist, say, using arbitrary inspection criteria leading to refusals (Baylis, Martens, and Nogueira 2009 and Grundke and Moser 2019).

Beyond these simple tests, establishing protectionism is more complex, in the presence of market imperfections. The presence of market imperfections justifies the presence of a standard-like NTM, but its exact level of stringency must be determined. Baldwin (1970), Baldwin (2000), and Fischer and Serra (2000) define the nonprotectionist standard as the one maximizing global welfare. A domestic social planner maximizing just domestic welfare could set up the optimum standard at a protectionist level, inducing a barrier to imports and hurting importers (Fischer and Serra 2000). The criterion is conceptually clear but difficult to implement empirically for at least two reasons. First, many standards and policies are set at once leading to the issue of how to account for their interactions and optimum levels. Second, what "global" means is quite subjective in terms of the country and market coverage (close substitutes, cross-price effects).

In addition, several authors have added political economy dimensions to the analysis of protectionism of technical measures. This addition generates more ambiguity in results. The standards can actually be set below their optimum level and be antiprotectionist, depending on rent-seeking influence and the ease of meeting the standard for example (Swinnen and Vandemoortele 2008 and 2011).

The last element to integrate is the transparency of standard-like NTMs. Nontransparent standards act as a tax on trade and reduce welfare, independently of their level of stringency. We discuss transparency next.

Transparency and Trade Costs

Transparency is an intuitive yet vague concept. In the context of the WTO, it means clarity in regulating economic activity and trade. The objective is to achieve greater clarity, predictability and information about trade policies, rules, and regulations of WTO Members. A pivotal element is the use of notifications. Under the SPS Agreement, notifications are used to inform other Members about new or changed regulations that may significantly affect their trading partners. Transparency under the SPS Agreement also includes answering reasonable questions, and publishing regulations. Trade costs induced by these NTMs can increase when these policies are not notified properly or not spelled out properly.

Beyond the WTO, many RTAs have transparency clauses or chapters on proper notifications, approval processes for biotechnology innovations, reciprocity, and other measures to reduce unnecessary transaction costs to meet these NTMs.

RTAs with "deep integration" objectives do reduce the price wedge (t *(NTM)*) (shown in figure 1) created by standard-like NTMs, as shown by Cadot, Gourdon, and Van Tongeren (2018), and Cadot and Gourdon (2016). The latter authors decompose the impact of NTMs on prices and supply and demand in a unique framework combining a price differential created by NTM policies, and the framework of Xiong and Beghin (2014) to decompose the impact of standard-like NTMs on supply and demand. They find that RTAs with more extensive transparency measures reduce the price wedge created by NTMs. Transparency remains difficult to measure, despite some attempt to formally conceptualize what it is (van Tongeren 2009).

While it is difficult to pin down an estimate of the cost of the lack of transparency, recent studies (Lejárraga, Shepherd, and van Tongeren 2013; Ing, Cadot, and Walz 2018) have estimated the implicit reduction in trade cost from transparency efforts in NTMs, often achieved through deep integration. Several studies rely on a gravity approach using variation in perceived government transparency broadly defined. Lejárraga, Shepherd, and van

Tongeren (2013) reviewed a large number of RTAs and collected their transparency provisions (e.g., notification requirements for SPS and TBT). The collected variables are incorporated in a gravity framework to gauge their effects on bilateral trade flows. Not surprisingly, the transparency provisions do facilitate trade with RTA members.

Ing et al. follow Wolfe (2013) and his three levels of transparency requirements in the WTO (early requirements through notification obligations in the GATT, monitoring through countries policy reviews, and finally dissemination of information through web-based instruments and portals). Portals are mandated by the 2014 WTO Trade Facilitation Agreement [from the "Bali" agreement, see WTO (2014)]. The latter information allows for direct measurement of transparency measures rather than perceptions using NTM inventories. Ing, Cadot, and Walz (2018) construct a transparency index for 187 countries, available in the appendix S1 of Ing, Cadot, and Walz (2018). The index is currently a cross section index but could be updated into a panel indicator as time elapses. The WTO Trade Facilitation Agreement (TFA) entered into force in 2017. The authors show unsurprisingly that OECD countries tend to have the highest level of transparency given their institutional capacity. Several measures included in their index could be easily updated over time from 2017 on, such as the existence of a TFA portal to provide a partial measure of transparency.

The measures developed by Ing, Cadot, and Walz (2018) correlate imperfectly among themselves and with government transparency scores from the World Economic Forum for its global competitiveness index and the World Bank's policy and institutional assessment (see appendix S1 for sources). These new transparency measures and index of Ing, Cadot, and Walz (2018) could be used in the typical gravity framework to characterize the impact of transparency on trade flows. The lack of time variation is an issue. The Global Competitiveness index of the World Bank, along with the Country Policy and Institutional Assessment indices, have time variation as an asset. Transparency measures are important for agriculture in the case of approval of biotech products for example. It features prominently in new trade agreements like the China-US Phase One agreement (U.S. Trade Representative 2020).

Promising Research Directions on Trade Costs

Gene Editing and Trade

A promising area of research on agricultural trade cost originates with biotechnology and new plant breeding technologies (NPBTs). New and more precise biotechnology tools have emerged to create novel food or attributes in a more targeted way (Qaim 2020). These new tools seemed to be able to avoid the missteps, which plagued GMO innovations in agriculture and food markets and their low acceptability among consumers in many countries, including the United States. These NPBTs are key to maximize agriculture's productivity, profitability, and sustainability to supply a continually increasing world demand for protein and oil for feed, fuel, and food (Qaim 2020). NPBTs are more precise tools to change the genome of plants. They often use the plant's own genome or the genome of related plants through cisgenesis. Despite the safety of these "gene-editing" techniques, new evidence suggests they may be controversial with environmental groups, and consumers, although not as much as GMOs were (National Academies of Sciences, Engineering, and Medicine 2016; Caputo, Lusk, and Kilders 2020 and Marette, Disdier, and Beghin 2020). These apprehensions are internationally present (Marette, Disdier, and Beghin 2020; Qaim 2020 and Schmidt, Belisle, and Frommer 2020).

There are emerging frictions over NPBTs used to innovate in agriculture and food markets (National Academies of Sciences, Engineering, and Medicine 2016; Bunge and Dockser Marcus 2018; Bain et al. 2019; Martin-Laffon, Kuntz, and Ricroch 2019; Qaim 2020 and Schmidt, Belisle, and Frommer 2020). Novel food and attributes in agricultural goods must be assessed for the potential risk they may create for human health and the environment. Regulations in many countries are process oriented rather than product oriented, and legacies of GMO regulation (Schaefer 2020 and Schmidt, Belisle, and Frommer 2020). Even in the United States, novel foods obtained through transgenic biotechnology are regulated differently than the same novel foods obtained through conventional breeding or gene-edited techniques assimilated to mutagenesis. Despite this similarity, some consumers may view these novel foods as different and may want to see them labeled. Given the vast differences across countries and culture and regulations, asynchronous approvals and heterogeneous regulations will prevail. A redux of the GMO scenario is predictable with import refusals, foregone trade and welfare opportunities for consumers, innovators, and farmers because of asynchronous and slow approvals or approvals for different uses (Qaim 2009, 2020; Disdier and Fontagné 2010; de Faria and Wieck 2015; and Henseler et al. 2013). This area is ripe for more case studies as new foods and varieties are emerging using NPBTs.

Integrating Components of Transport Systems

In the transport costs section, we have proposed a series of enhancements to the traditional use of distance as a proxy for the cost of transportation, depending on context and the data available. Needed topics of research in agricultural transportation that could be used to improve our understanding of agricultural markets and trade are how recently imposed transportation policies might affect agricultural shipments, and if performance improvements to transportation systems as a whole provide benefits (or detriments) to agricultural shipments.

Both the US electronic logging device mandate for trucks and the International Maritime Organization's 2020 low sulfur fuel mandate for marine shipping are thought to increase the costs of their respective modes (Kass et al. 2019; Thayer et al. 2019 and Wade, Roka, and Sprouse 2019). There is likely some incidence between shippers and carriers, and the relative costs of US internal and external transportation costs compared to other countries have changed. While research does exist for these policies in general, there is little research currently available evaluating the effects on agricultural exports and agricultural markets.

Transportation system performance has improved over time whether the measurements are speed, volumes, or the quality of the journey itself. However, agricultural shipping rates are often less than those of manufacturing goods by weight or volume. Carriers have less incentives to focus performance improvements on lower revenue shipments beyond efficiency gains within their own operations. Alternatively, smart systems record and send data to carriers about transportation conditions and events which allows carriers to monitor service quality and performance more closely. They also improve communication among customs agents, shippers, and carriers. Therefore, these systems might provide larger returns to perishable agricultural goods by improving safety and quality than dry manufactured goods. Heterogeneous returns to smart technologies and systemwide performance improvements have implications for both trade in agricultural goods as well as a better understanding of the benefits of smart technologies in supply chains more generally.

Mainstreaming and Improving Estimation Methods

Advances in gravity-based analyses of trade flows could be more routinely applied to agricultural trade cost issues. We have in mind improvements in the decomposition of trade costs into their intra-national and international components. For example, Duan and Grant (2012) estimated trade costs in agricultural trade using Novy's approach to bilateral trade and border effect (Novy 2013). Novy himself builds upon an approach developed by Head and Ries (2001), and Head and Mayer (2002) and Chen and Novy (2011) to measure "free-ness" or "phy-ness" and a proper measure of internal trade cost (within a country) and those trade costs crossing a border between two countries, called the border effect. Using the approach one can derive an average implied bilateral trade cost factor between countries just using observed panel trade data and CES elasticities. The trade cost factor can be used as a left-hand side variable in a regular gravity framework using the usual trade cost determinants. The main drawback of this approach is the potential sensitivity of the trade cost estimate to the value of the CES elasticity values.

Another recent improvement into this decomposition is the development of relative transportation costs into an internal and international transportation element using an approach reminiscent of Novy, with a focus on internal distance and allowing the bilateral distance effect to vary over time (Yotov 2012 and Yotov et al. 2016). This approach could readily be used in agricultural trade cost analysis using a gravity approach.

Estimates of trade cost based on gravity equation approaches tend to yield excessively large trade cost estimates, which can appear implausible when introduced in calibrated models for a validation exercise (Balistreri and Hillberry 2006). The implied resources devoted to trading goods are extremely large. Validating agricultural trade cost estimates in calibrated models could be an enlightening exercise to gauge their plausibility.

There is still a lack of attention on separate and distinct effects of NTMs on import unit cost, supply, and demand. Their impact on welfare is not sufficiently investigated, as authors focus on trade effects, which we have argued are not that informative or could be misleading. Health/environmental costs and benefits should be more systematically incorporated into analyses. The disentanglement proposed by Cadot, Gourdon, and Van Tongeren (2018) identifies the separate effects on import unit value, supply and demand of NTMs. The method requires panel data, which have become increasingly available. They do not consider welfare, however. The welfare analyses proposed by Disdier and Marette (2010), Van Tongeren, Beghin, and Marette (2009), and Wilson and Antón (2006) are clearly feasible and could be more frequently implemented. They account for market imperfections and/or risk and are more informative.

Finally, the aggregation of various standard-like NTMs remains a major challenge. Various measures such as frequency and counts of NTMs are inadequate to capture stringency, regulatory heterogeneity, or the cumulative effect of various measures. This topic is challenging, in the higher-risk–higher-payoff category. A major breakthrough on meaningful aggregation and without requiring heaps of data would advance the field.

Conclusions

Agricultural trade costs are significant as many agricultural goods are low-value, bulky, and perishable. We examined three salient cost components (transportation, tariffs, and NTMs) as they would be captured in a calibrated model or in an econometric estimation. Transportation cost is difficult to capture in a realistic way because it is heterogeneous across goods, transportation modes and time. Nevertheless, we proposed several concrete ways to improve on current practice, often limited to cross-sectional distance. Transportation distortions remain large and unaddressed. Much could be gained by liberalizing transportation services.

Second, standard-like NTMs are hard to account for in an exhaustive way with limitations on aggregation, data availability, and the difficulty to measure their effects on consumers and market imperfections. As for transportation costs, we reviewed and suggested better ways to investigate these NTMs. Policy recommendations focused on detecting lurking protectionism and promoting transparency in policies. Finally, tariffs have fallen dramatically and abstracting from the unilateralism of the Trump administration, their global levels will continue to converge to nearly negligible levels through large RTAs. This is also consistent with robust policy recommendations. Finally, we are hopeful the suggested research directions will find some interested readers and takers.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Acknowledgments

Without implicating them, we thank C. Gundersen and I. Sheldon for detailed comments on an earlier draft, which considerably improved our exposition, and E. Balistreri, D. Blandford, JC Bureau, AC Disdier, B. Goodwin, T. Grennes, S. Marette, D. Orden, N. Piggott, S. Tangerman, W. Thurman, D. van der Mensbrugghe, F. van Tongeren, Y. Yotov, and W. Wilson for discussions on related topics, which shaped our perspective on agricultural trade costs.

References

Anderson, James E., and J. Peter Neary. 1992. Trade Reform with Quotas, Partial Rent Retention, and Tariffs. *Econometrica: Journal of the Econometric Society* 60(1): 57–76.

Anderson, James E., and Eric Van Wincoop. 2004. Trade Costs. *Journal of Economic Literature* 42(3): 691–751.

Anderson, Kym, Will Martin, and Dominique Van der Mensbrugghe Market and Welfare Implications of Doha Reform Scenarios. *Agricultural Trade Reform and the Doha Development Agenda* 2006: 333–399.

Auboin, Marc, and Michele Ruta. 2013. The Relationship between Exchange Rates and International Trade: A Literature Review. *World Trade Review* 12: 577–605.

Bain & Company and the World Bank. 2013. *Enabling Trade: Valuing Growth Opportunities*. Geneva: World Economic Forum.

Bain, Carmen, Sonja Lindberg, and Theresa Selfa. 2020. Emerging Sociotechnical Imaginaries for Gene Edited Crops for Foods in the United States: Implications for Governance. *Agriculture and Human Values* 37: 265–279.

Baldwin, Richard. 2000. Regulatory Protectionism, Developing Nations, and a Two-Tier World Trade System. *Brookings Trade Forum*: 237–293.

Baldwin, Robert Edward. 1970. *Nontariff Distortions of International Trade*. Washington, DC: Brookings Institution.

Balistreri, Edward J., Chad E. Hart, Dermot J. Hayes, Minghao Li, Lee Schulz, David A. Swenson, Wendong Zhang, and John M. Crespi. "The Impact of the 2018 Trade Disruptions on the Iowa Economy." (Briefing Paper 18-BP-25, Center for Agricultural and Rural Development, Iowa State University, Ames, IA, 2018.)

Balistreri, Edward J., and Russell H. Hillberry. 2006. Trade Frictions and Welfare in the Gravity Model: How Much of the Iceberg Melts? *Canadian Journal of Economics/Revue Canadienne d'économique* 39(1): 247–265.

Barichello, Richard R. 2000. A Review of Tariff Rate Quota Administration in Canadian Agriculture. *Agricultural and Resource Economics Review* 29: 103–114.

Baylis, Kathy, Andrea Martens, and Lia Nogueira. 2009. What Drives Import Refusals? *American Journal of Agricultural Economics* 91(5): 1477–1483.

Beghin, John C., and Amani Elobeid. "Analysis of the US Sugar Program." Research Report, American Enterprise Institute, 2017.

Beghin, John C., and Larry S. Karp. 1992. Piecemeal Trade Reform in Presence of Producer-Specific Domestic Subsidies. *Economics Letters* 39(1): 65–71.

Beghin, John Christopher, Anne-Célia Disdier, and Stéphan Marette. 2015a. Trade Restrictiveness Indices in Presence of Externalities: An Application to Non-Tariff Measures. *Canadian Journal of Economics* 48(4) (2015):: 1513–1536.

Beghin, John C., Miet Maertens, and Johan Swinnen. 2015b. Nontariff Measures and Standards in Trade and Global Value Chains. *Annual Review of Resource Economics* 7(1) (2015b):: 425–450.

Beghin, John Christopher, ed. 2017. *Nontariff Measures and International Trade*. London: World Scientific Imperial College Press.

Behzadi, Golnar, Michael Justin O'Sullivan, Tava Lennon Olsen, and Abraham Zhang. 2018. Agribusiness Supply Chain Risk Management: A Review of Quantitative Decision Models. *Omega* 79: 21–42.

Bellora, Cecilia, and Lionel Fontagné. 2019. Shooting oneself in the Foot? US Trade Policy Coping with Global Value Chains. *La Lettre du CEPII* 398: 1–4.

Bensassi, Sami, Laura Márquez-Ramos, Inmaculada Martínez-Zarzoso, and Celestino Suárez-Burguet. 2015. Relationship between Logistics Infrastructure and Trade: Evidence from Spanish Regional Exports. *Transportation Research Part A* 72: 47–61.

Blonigen, Bruce A., and Wesley W. Wilso. 2018. *Handbook of International Trade and Transportation*. Cheltanham, UK: Edward Elgar Publishing.

Bouët, Antoine, Jean-Christophe Bureau, Yvan Decreux, and Sébastien Jean. 2005. Multilateral Agricultural Trade Liberalisation: The Contrasting Fortunes of Developing Countries in the Doha Round. *World Economy* 28(9): 1329–1354.

Boughner, Devry S., Harry de Gorter, and Ian M. Sheldon. 2000. The Economics of Two-Tier Tariff-Rate Import Quotas in Agriculture. *Agricultural and Resource Economics Review* 29(1): 58–69.

Bown, Chad P., and Douglas A. Irwin. 2019. Trump's Assault on the Global Trading System: And Why Decoupling from China Will Change Everything. *Foreign Affairs* 98: 125–136.

Brenton, Paul. 2003. *Integrating the Least Developed Countries into the World Trading System: The Current Impact of EU Preferences under Everything but Arms*. Washington DC: The World Bank.

Brink, Lars. "Two Indicators, Little in Common, Same Name: Market Price Support." *CAP Reform*, 2018. http://capreform.eu/two-indicators-little-in-common-same-name-market-price-support. (accessed March 25, 2019).

Brink, Lars, and David Orden. "Taking Stock and Looking Forward on Domestic Support in Agriculture." (Commissioned Paper CP-23, International Agricultural Trade Research Consortium, St. Paul, MN, 2020).

Bunge, J., and A. Dockser Marcus. "Is this Tomato Engineered? Inside the Coming Battle over Gene-Edited Food." *Wall Street Journal*, April 15, 2018. https://www.wsj.com/articles/is-this-tomato-engineered-inside-the-coming-battle-over-gene-edited-food-1523814992.

Bureau, Jean-Christophe, Houssein Guimbard, and Sébastien Jean. 2019. Competing Liberalizations: Tariffs and Trade in the Twenty-First Century. *Review of World Economics* 155(4): 707–753.

Bureau, Jean-Christophe, Sébastien Jean, and Alan Matthews. 2006. The Consequences of Agricultural Trade Liberalization for Developing Countries: Distinguishing Between Genuine Benefits and False Hopes. *World Trade Review* 5(2): 225–249.

Bureau, Jean-Christophe, Stephan Marette, and Alessandra Schiavina. 1998. Non-Tariff Trade Barriers and Consumers' Information: The Case of EU-US Trade Dispute on Beef. *European Review of Agricultural Economics* 25(4): 437–462.

Cadot, Olivier, and Julien Gourdon. 2016. Non-tariff Measures, Preferential Trade Agreements, and Prices: New Evidence. *Review of World Economics* 152: 227–249.

Cadot, Olivier, Julien Gourdon, and Frank Van Tongeren. "Estimating Ad Valorem Equivalents of Non-Tariff Measures: Combining Price-Based and Quantity-Based Approaches." OECD Trade Policy Paper no.215 OECD Publishing, Paris, 2018. https://dx.doi.org/10.1787/f3cd5bdc-en.

Calvin, Linda, and Barry Krissoff. 1998. Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and U.S.-Japanese Apple Trade. *Journal of Agricultural and Resource Economics* 23(2): 351–366.

Caputo, V., J. Lusk, and V. Kilders. "Consumer Acceptance of Gene Edited Foods: A Nationwide Survey on US Consumer Beliefs, Knowledge, Understanding, and Willingness to Pay for Gene-Edited Foods under Different Treatments." FMI Foundation Report, Arlington, VA, 2020.

Chen, Bowen, Nelson B. Villoria, and Tian Xia. 2020. Tariff Quota Administration in China's Grain Markets: An Empirical Assessment. *Agricultural Economics* 51(2): 191–206.

Chen, Natalie, and Dennis Novy. 2011. Gravity, Trade Integration, and Heterogeneity across Industries. *Journal of International Economics* 85(2): 206–221.

Chepeliev, Maksym, Wallace E. Tyner, and Dominique van der Mensbrugghe. "How US Agriculture Will Fare Under the USMCA and Retaliatory Tariffs." Working Paper 84, Global Trade Analysis Project, 2018.

Conconi, Paola, Manuel García-Santana, Laura Puccio, and Roberto Venturini. 2018. From Final Goods to Inputs: The Protectionist Effect of Rules of Origin. *American Economic Review* 108(8): 2335–2365.

Coyle, William, William Hall, and Nicole Ballenger. 2001. Transportation Technology and the Rising Share of US Perishable Food Trade. In *Changing Structure of Global Food Consumption and Trade*, ed. Anita Regmi, 31–40. Washington DC: USDA Economic Research Service.

de Faria, Rosane Nunes, and Christine Wieck. 2015. Empirical Evidence on the Trade Impact of Asynchronous Regulatory Approval of New GMO Events. *Food Policy* 53: 22–32.

de Melo, Jaime, and Alessandro Nicita, eds. 2018. *Non-Tariff Measures: Economic Assessment and Policy Options for Development*. Geneva: United Nations Conference on Trade and Development (UNCTAD) Publications.

Disdier, Anne-Célia, and Lionel Fontagné. 2010. Trade Impact of European Measures on GMOs Condemned by the WTO Panel. *Review of World Economics* 146: 495–514.

Disdier, Anne-Célia, and Keith Head. 2008. The Puzzling Persistence of the Distance Effect on Bilateral Trade. *Review of Economics and Statistics* 90(1): 37–48.

Disdier, Anne-Célia, and Stéphan Marette. 2010. The Combination of Gravity and Welfare Approaches for Evaluating Nontariff Measures. *American Journal of Agricultural Economics* 92(3): 713–726.

Disdier, Anne-Célia, and Frank Van Tongeren. 2010. Non-tariff Measures in Agri-Food Trade: What Do the Data Tell us? Evidence from a Cluster Analysis on OECD Imports. *Applied Economic Perspectives and Policy* 32(3): 436–455.

Dixit, Avinash. 1989. Hysteresis, Import Penetration, and Exchange Rate Pass-through. *The Quarterly Journal of Economics* 104(2): 205–228.

Duan, Shuwen, and Jason H. Grant. "Agricultural Trade Costs: 1965–2010." Mimeo (No. 323–2016-11785), 2012.

Elliott, Kimberly Ann, and Thomas O. Bayard. 1994. *Reciprocity and Retaliation in US Trade Policy*. Peterson Institute Press: All Books.

Elliott, Kimberly Ann, and J. David Richardson. 1997. Determinants and Effectiveness of "Aggressively Unilateral" US Trade Actions. In *The Effects of US Trade Protection and Promotion Policies* 215–243. Chicago: University of Chicago Press.

Fajgelbaum, Pablo D., Pinelopi K. Goldberg, Patrick J. Kennedy, and Amit K. Khandelwal. 2020. The Return to Protectionism. *The Quarterly Journal of Economics* 135(1): 1–55.

Falvey, Rodney E. 1988. Tariffs, Quotas and Piecemeal Policy Reform. *Journal of International Economics* 25(1–2): 177–183.

Feenstra, Robert C., and Chang Hong. "China's Import Demand for Agricultural Products: The Impact of the Phase One Trade Agreement." Working Paper No. 27383, National Bureau of Economic Research, 2020.

Fischer, Ronald, and Pablo Serra. 2000. Standards and Protection. *Journal of International Economics* 52(2): 377–400.

Frittelli, John. "Shipping Under the Jones Act: Legislative and Regulatory Background." CRS Report No. R45725. Washington, DC: Congressional Research Service, 2019.

Gibson, Paul, John Wainio, Daniel Whitley, and Mary Bohman. "Profiles of Tariffs in Global Agricultural Markets." Agricultural Economic Report No. 796, Market and Trade Economics Division, U.S. Department of Agriculture, Economic Research Service, 2001.

Goldin, Ian, and Dominique Van der Mensbrugghe. 1995. The Uruguay Round: An Assessment of Economy Wide and Agricultural Reforms. *The Uruguay Round and the Developing Economies* 307: 25–52.

Goodwin, Barry K., and Nicholas E. Piggott. 2001. Spatial Market Integration in the Presence of Threshold Effects. *American Journal of Agricultural Economics* 83(2): 302–317.

Grant, Jason, and Shawn Arita. "Sanitary and Phytosanitary Measures: Assessment, Measurement and Impact." Commissioned Paper CP-21, International Agricultural Trade Research Consortium, St. Paul, MN, 2017.

Grundke, Robert, and Christoph Moser. 2019. Hidden Protectionism? Evidence from Non-tariff Barriers to Trade in the United States. *Journal of International Economics* 117: 143–157.

Halaszovich, Tilo F., and Aseem Kinra. 2018. The Impact of Distance, National Transportation Systems and Logistics Performance on FDI and International Trade Patterns: Results from Asian Global Value Chains. *Transport Policy* online.

Halff, Antoine, Lara Younes, and Tim Boersma. 2019. The Likely Implications of the New IMO Standards on the Shipping Industry. *Energy Policy* 126: 277–286.

Hatta, Tatsuo. 1977. A Recommendation for a Better Tariff Structure. *Econometrica: Journal of the Econometric Society* 45(8): 1859–1869.

Head, Keith, and Thierry Mayer. 2002. On Illusory Border Effect and Freeness-Phyness. In *The Gravity Model in International Trade: Advances and Applications*, ed. Peter

A.G. Van Bergeijk and Steven Brakman, 165–192. Cambridge: Cambridge University Press.

Head, Keith, and John Ries. 2001. Increasing Returns Versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade. *The American Economic Review* 91(4): 858–876.

Hejazi, Mina, Jason H. Grant, and Everett Peterson. 2017. Tariff Changes and the Margins of Trade: A Case Study of US Agri-Food Imports. *Journal of Agricultural and Resource Economics* 42: 68–89.

Henseler, Martin, Isabelle Piot-Lepetit, Emanuele Ferrari, Aida Gonzalez Mellado, Martin Banse, Harald Grethe, Claudia Parisi, and Sophie Hélaine. 2013. On the Asynchronous Approvals of GM Crops: Potential Market Impacts of a Trade Disruption of EU Soy Imports. *Food Policy* 41: 166–176.

Heumueller, Dirk, and Tim Josling. 2004. Trade Restrictions on Genetically Engineered Foods: the Application of the TBT Agreement. In *The Regulation of Agricultural Biotechnology*, ed. Robert E. Evenson and Vittorio Santaniello. Wallingford, UK: Cabi Publishing.

Hillman, Arye L. 1989. *The Political Economy of Protection*. Reading, UK: Harwood Academic Publishers; Abingdon UK: Taylor and Francis, 2013). Citations refer to the Taylor and Francis edition.

Hooker, Neal H., and Julie A. Caswell. 1999. A Framework for Evaluating Non-tariff Barriers to Trade Related to Sanitary and Phytosanitary Regulation. *Journal of Agricultural Economics* 50(2): 234–246.

Hummels, David. 2007. Transportation Costs and International Trade in the Second Era of Globalization. *Journal of Economic Perspectives* 21(3): 131–154.

Hummels, David, Volodymyr Lugovskyy, and Alexandre Skiba. 2009. The Trade Reducing Effects of Market Power in International Shipping. *Journal of Development Economics* 89(1): 84–97.

Hummels, David, and Alexandre Skiba. 2004. Shipping the Good Apples out? An Empirical Confirmation of the Alchian-Allen Conjecture. *Journal of Political Economy* 112(6): 1384–1402.

Ing, Lili Yan, Olivier Cadot, and Janine Walz. 2018. Transparency in Non-tariff Measures: An International Comparison. *The World Economy* 41: 884–912.

Josling, Timothy. "Who's Afraid of the GMOs? EU-US Trade Disputes over Food Safety and Biotechnology." Paper Presented at the Center for International Studies and the European Center of California, Los Angeles, CA, March 11, 1999.

Josling, Timothy E., Donna Roberts, and David Orden. 2004. *Food Regulation and Trade: Toward a Safe and Open Global System*. Washington, DC: Institute for International Economics.

Kass, Michael, John Thomas, Scott Sluder, and Timothy Theiss. "A Guide to Fuel, Lubricant, and Engine Concerns Relative to the IMO 2020 Fuel Oil Sulfur Reduction Mandate." Report No. ORNL/SPR-2019/1406, Oak Ridge National Laboratory, Oak Ridge, TN, 2019.

Kherallah, Mylene, and John Beghin. 1998. US Trade Threats: Rhetoric or War? *American Journal of Agricultural Economics* 80(1): 15–29.

Korinek, Jane, and Mark Melatos. "Trade Impacts of Selected Regional Trade Agreements in Agriculture." Trade Policy Paper No. 87, OECD Publishing, Paris, 2009.

Korinek, Jane, and Patricia Sourdin. 2010. Clarifying Trade Costs: Maritime Transport and its Effect on Agricultural Trade. *Applied Economic Perspectives and Policy* 32(3): 417–435.

Lejárraga, Iza, Ben Shepherd, and Frank van Tongeren. 2013. Transparency in Nontariff Measures: Effects on Agricultural Trade. In *Nontariff Measures with Market Imperfections: Trade and Welfare Implications (Frontiers of Economics and Globalization, Vol. 12)*, ed. John C. Beghin, 99–125. Bingley: Emerald Group Publishing Limited.

Lence, Sergio H., GianCarlo Moschini, and Fabio Gaetano Santeramo. 2018. Threshold Cointegration and Spatial Price Transmission when Expectations Matter. *Agricultural Economics* 49(1): 25–39.

Li, Yuan, and John C. Beghin. 2012. A Meta-Analysis of Estimates of the Impact of Technical Barriers to Trade. *Journal of Policy Modeling* 34(3): 497–511.

——. 2014. Protectionism Indices for Non-tariff Measures: An Application to Maximum Residue Levels. *Food Policy* 45: 57–68.

Liu, Lan, and Chengyan Yue. 2013. Investigating the Impacts of Time Delays on Trade. *Food Policy* 39: 108–114.

Magee, Christopher S.P. 2008. New Measures of Trade Creation and Trade Diversion. *Journal of International Economics* 75(2): 349–362.

Marette, Stéphan. 2016. Non-tariff Measures when Alternative Regulatory Tools Can Be Chosen. *Journal of Agricultural & Food Industrial Organization* 14(1): 1–17.

Marette, Stéphan, Anne-Célia Disdier, and John C. Beghin. "How Do Consumers Perceive Gene-Edited Food? A Comparison of EU and US consumers' Willingness to Pay for Gene-Edited Apples". Agricultural Economics Staff Paper 2020–1. University of Nebraska Lincoln, 2020.

Martin, Will, and Kym Anderson. 2012. Export Restrictions and Price Insulation during Commodity Price Booms. *American Journal of Agricultural Economics* 94(2): 422–427.

Martin, Will J., and Joseph W. Glauber. 2020. Trade Policy and Food Security. In *COVID-19 and Trade Policy: Why Turning Inward Won't Work*, ed. Richard Baldwin and Simon J. Evenett, 89–101. London: CEPR Press.

Martin-Laffon, Jacqueline, Marcel Kuntz, and Agnès E. Ricroch. 2019. Worldwide CRISPR Patent Landscape Shows Strong Geographical Biases. *Nature Biotechnology* 37: 601–621.

Mattoo, Aaditya, Alen Mulabdic, and Michele Ruta. "Trade Creation and Trade Diversion in Deep Agreements." Working Paper 8206, World Bank Policy Research, 2017.

Mattoo, Aaditya, and Robert W. Staiger. 2020): online. Trade Wars: What Do they Mean? Why Are they Happening Now? What Are the Costs? *Economic Policy*: eiaa013. https://doi.org/10.1093/epolic/eiaa013.

Moschini, Giancarlo. 1991. Economic Issues in Tariffication: An Overview. *Agricultural Economics* 5(2): 101–120.

National Academies of Sciences, Engineering, and Medicine. 2016. *Genetically Engineered Crops: Experiences and Prospects*. Washington, DC: The National Academies Press.

Neary, J. Peter. 2007. Simultaneous Reform of Tariffs and Quotas. *Review of International Economics* 15(1): 37–44.

Nguyen, Hong-Oanh, and Jose Tongzon. 2010. Casual Nexus between the Transport and Logistics Sector and Trade: The Case of Australia. *Transport Policy* 17(3): 135–146.

Novy, Dennis. 2013. Gravity Redux: Measuring International Trade Costs with Panel Data. *Economic Inquiry* 51(1): 101–121.

OECD. "COVID-19 and International Trade: Issues and Actions." 2020. Paris, France: OECD PUBLICATION.

Orden, David. Multilateral rules for food and agricultural trade. In *Current Issues in Global Agricultural and Trade Policy: A Tribute to the Work of Timothy Josling*, ed. D. Blandford and S. Tangermann. London: World Scientific Publishing Co. Forthcoming).

Pascali, Luigi. 2017. The Wind of Change: Maritime Technology, Trade, and Economic Development. *American Economic Review* 107(9): 2821–2854.

Qaim, Matin. 2009. The Economics of Genetically Modified Crops. *Annual Review of Resource Economics* 1(1): 665–694.

Qaim, Matin. 2020. Role of New Plant Breeding Technologies for Food Security and Sustainable Agricultural Development. *Applied Economic Perspectives and Policy* 42 (2): 129–115.

Ramos, Maria Priscila, Jean-Christophe Bureau, and Luca Salvatici. "Shipping the good beef out: EU trade liberalization to Mercosur exports." Working Paper 7215, TRADEAG - Agricultural Trade Agreements, 2007.

Santeramo, Fabio Gaetano, and Emilia Lamonaca. 2019. The Effects of Non-tariff Measures on Agri-Food Trade: A Review and Meta-Analysis of Empirical Evidence. *Journal of Agricultural Economics* 70(3): 595–617.

Schaefer, Matthew. "U.S. Strategies to Ensure that Gene-Edited Crops and Food Avoid the Regulatory Stigma and International Trade Obstacles of Genetically-Modified Crops and Food." Mimeo, University of Nebraska Lincoln, 2020.

Schmidt, Sarah M., Melinda Belisle, and Wolf B. Frommer. 2020. The Evolving Landscape around Genome Editing in Agriculture: Many Countries Have Exempted or Move to Exempt Forms of Genome Editing from GMO Regulation of Crop Plants. *EMBO Reports*: e50680.

Scoppola, Margherita, Valentina Raimondi, and Alessandro Olper. 2018. The Impact of EU Trade Preferences on the Extensive and Intensive Margins of Agricultural and Food Products. *Agricultural Economics* 49(2): 251–263.

Sheldon, Ian M. 2002. Regulation of Biotechnology: Will we Ever 'Freely' Trade GMOs? *European Review of Agricultural Economics* 29(1): 155–176.

Smith, Vincent H., and Joseph W. Glauber. 2019. The Future of US Farm Policy. *EuroChoices* 18(1): 42–48.

Smith, Vincent H., Joseph W. Glauber, and Barry K. Goodwin, eds. 2018. *Agricultural Policy in Disarray*. Lanham, MD: Rowman & Littlefield.

Summers, Lawrence H. 2014. US Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound. *Business Economics* 49(2): 65–73.

Swinnen, Johan F.M., and Thijs Vandemoortele. 2008. The Political Economy of Nutrition and Health Standards in Food Markets. *Review of Agricultural Economics* 30(3): 460–468.

——. 2011. Trade and the Political Economy of Food Standards. *Journal of Agricultural Economics* 62(2): 259–280.

Tadesse, Bedassa, and Bichaka Fayissa. 2008. The Impact of African Growth and Opportunity Act (Agoa) on US Imports from Sub-Saharan Africa (SSA). *Journal of International Development: The Journal of the Development Studies Association* 20(7): 920–941.

Thayer, Anastasia, Charley Martinez, Justin Benavidez, and David Anderson. "The Impact of ELD Trucking Regulations on Cattle Prices in the South." Paper presented at the Southern Agricultural Economics Association Annual Meeting. Birmingham, AL, February 2019.

Tian, Huilan. 2003. Eco-Labelling Scheme, Environmental Protection, and Protectionism. *Canadian Journal of Economics* 36(3): 708–725.

UNCTAD. "The International Classification of Non-tariff Measures." Publication UNCTAD/DITC/TAB/2019/5, United Nations Conference on Trade and Development, Geneva, Switzerland, 2019.

U.S. Trade Representative. "Economic and Trade Agreement between The Government of The United States of America and The Government of The People's Republic of China." Washington, DC: Office of the U.S. Trade Representative, January 15, 2020.

Van der Mensbrugghe, Dominique, and John C. Beghin. 2004. Global Agriculture: What Is at Stake? In *Global Agricultural Trade & Developing Countries*, ed. M. Ataman Aksoy and John C. Beghin, 115–138. Washington, DC: The World Bank.

van Tongeren, Frank "Transparency in the Design of Non-Tariff Measures and the Cost of Market Entry: Conceptual Framework." (OECD Working Party of the Trade Committee TAD/TC/WP(2009)33, Paris, 2009.)

Van Tongeren, Frank, John Beghin, and Stephan Marette. "A Cost-Benefit Framework for the Assessment of Non-Tariff Measures in Agro-Food Trade." (Working Paper #21, OECD Food, Agriculture and Fisheries, (2009).

Villareal, M. Angeles. Mexico's Free Trade Agreements. CRS Report No. R40784. Washington, DC: Congressional Research Service, 2017.

Viner, Jacob. 1950. *The Customs Union Issue*. Washington, DC: Carnegie Endowment for International Peace; New York: Oxford University Press.

Wade, Tara, Fritz Roka, and Craig Sprouse. "The Electronic Logging Devices Mandate and Hours of Service for Produce Haulers." Extension Document FE1052, University of Florida IFAS Extenstion, 2019.

Wales, Terence J., and Alan Donald Woodland. 1983. Estimation of Consumer Demand Systems with Binding Nonnegativity Constraints. *Journal of Econometrics* 21: 263–285.

Williams, Brock R. "African Growth and Opportunity Act (AGOA): Background and Reauthorization." CRS Report No. R43173. Washington, DC: Congressional Research Service, 2015.

Wilson, Norbert L.W., and Jesús Antón. 2006. Combining Risk Assessment and Economics in Managing a Sanitary-Phytosanitary Risk. *American Journal of Agricultural Economics* 88(1): 194–202.

Wolfe, Robert. "Let the Sun Shine at the WTO: How Transparency Bring the Trading System into Life." (Staff Working Paper ERSD 2013–03, World Trade Organization, Geneva, 2013).

World Trade Organization (WTO). "Protocol Amending the Marrakesh Agreement Establishing the World Trade Organization. Decision of 27 November 2014." Document WT/L940, 2014.

WTO. 2019. World Tariff Profiles. 2019. co-publication of the WTO, ITC and UNCTAD: GENEVA, SWITZERLAND.

——. 2020a. *WTO-Safeguard Measures*. https://www.wto.org/english/tratop_e/safeg_e/safeg_e.htm#statistics (accessed July 29, 2020).

——. 2020b. "Standards, Regulations, and COVID-19 – What Actions Taken by WTO Members?" May 2, 2020. WTO Secretariat.

WTO Committee on Sanitary and Phytosanitary Measures. "Review of the Operation and Implementation of the SPS Agreement. Draft Report of the Committee-Part B." Document G/SPS/W/313/Rev.3/Add.1. 15 June 2020 (20–4215).

WTORTA. 2020. Regional Trade Agreements Gateway WTO. https://www.wto.org/english/tratop_e/region_e/region_e.htm. Accessed October 2020. WTO, GENEVA, Switzerland.

Xiong, Bo, and John Beghin. 2014. Disentangling the Demand-Enhancing & Trade-Cost Effects of Maximum Residue Regulations. *Economic Inquiry* 52(3): 1190–1203.

Yotov, Yoto V. 2012. A Simple Solution to the Distance Puzzle in International Trade. *Economics Letters* 117(3): 794–798.

Yotov, Yoto V., Roberta Piermartini, José-Antonio Monteiro, and Mario Larch. 2016. *An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model. Online Revised Version*. (Vol., Vol 1 &2. Geneva: United Nations and World Trade Organization.

Yue, Chengyan, and John C. Beghin. 2009. The Tariff Equivalent and Forgone Trade Effects of Prohibitive Technical Barriers to Trade. *American Journal of Agricultural Economics* 91(4): 930–941.

Yue, Chengyan, John Beghin, and Helen H. Jensen. 2006. Tariff Equivalent of Technicsal Barriers to Trade with Imperfect Substitution and Trade Costs. *American Journal of Agricultural Economics* 88(4): 947–960.