On Non-Tariff Measures and Changes in Trade Routes: From North-North to South-South Trade?

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[SHORT VERSION]

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Executive summary

Agri-food trade has assumed greater relevance over time, in terms of the values traded and the number of participating countries and commodities. More importantly, **there has been a trend reversal in trade patterns, with remarkable growth in trade from developing countries and the emergence of new trade routes**. The changes in agri-food trade are due to several factors, including economic globalisation, progressive trade liberalisation, and the reorganisation of policy interventions. **The proliferation of non-tariff measures (NTMs) is likely to be related to changes in trade patterns**. Indeed, NTMs may have contributed to the development of new dynamics in agri-food trade with geographic-specific effects, some positive and some negative.

The growing empirical literature on how NTMs affect agri-food trade provides **contrasting evidence, with some studies supporting the 'standards as catalysts' view, and others favouring the 'standards as barriers' explanation**. To the extent that NTMs can influence trade, understanding the prevailing effect, and the motivations behind one effect or the other, is a pressing issue.

A qualitative and quantitative review of a large portion of the existing empirical evidence on the effect of NTMs on agri-food trade shows that **heterogeneity in estimates may be explained by several factors, including the publication process and study-specific assumptions**. Some characteristics of the studies are correlated with positive significant estimates; others covary with negative significant estimates. Overall, we find that **the effects of NTMs vary across types of NTMs, proxies for NTMs, and the level of detail in the studies**.

During the last several decades (the 2000s, the 2010s), the number of sanitary and phytosanitary standards (SPSs) has grown exponentially, in terms of product coverage and number of implementing countries. The growth in SPSs is likely to have intensified the reshaping of global agri-food trade. Analysis of SPSs and trade of the most regulated commodities among developed and developing countries reveals that **SPSs tend to limit trade**, although the effect appears to depend on the type of trade partners involved. Interestingly, **SPSs implemented by developed countries tend to be more trade-impeding than those of the developing countries**. In addition, **SPSs tend to favor increases in agri-food trade among existing trade partners but inhibit the development of new trade relationships among countries**. **These effects are lower for the SPSs of developed countries**.

Our analysis also indicates that the **trade effects of SPSs are commodity- and measure-specific**. Divergences from the general trend (enhancement of intensive margins of trade, hindrance of extensive margins of trade) occur for certain commodities (seafood products) and for specific SPSs (requirements for post-production process, conformity assessment), if SPSs are set by developed countries. Large differences exist in the effects of SPS between developed and developing countries and across different trade partnerships. Thus, accounting for geo-economic differences is essential for policymakers to enhance the positive trade effects of SPSs and to limit their negative effects.

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Acronyms

AAEA	American Agricultural Economics Association
AJAE	American Journal of Agricultural Economics
ARG	Argentina
AUS	Australia
AVE	Ad valorem equivalent
BEL	Belgium-Luxembourg
BOL	Plurinational State of Bolivia
BRA	Brazil
BRIIC	
	Brazil, Russian Federation, Indonesia, India
C.I.	Confidence Interval
CAER	China Agricultural Economic Review
CAN	Canada
CEPII	Centre d'Études Prospectives et d'Informations Internationales
CER	China Economic Review
CHE	Switzerland
CHL	Chile
CHN	China
CJE	Canadian Journal of Economics
COG	Congo
CP	Conference Proceeding
CR	Trade creation
DEU	Germany
DNK	Denmark
DV	Trade diversion
EAAE	European Association of Agricultural Economists
EGY	Egypt
EI	Economic Inquiry
EM	Extensive margins of trade
EP	Entry Price
ERAE	European Review of Agricultural Economics
ERI	Economic Research International
ESP	Spain
ETEMs	Estimated trade effects of measures
EU	European Union
EUI RSCAS	European University Institute Robert Schuman Centre for Advanced Studies
EUN	European Union
F&O	Fats and Oils
f.e.	Fixed effects
FP	Food Policy
FRA	France
GBR	United Kingdom
GDP	Gross Domestic Product
HACCP	Hazard Analysis and Critical Control Points
HKG	Hong Kong
HMR	Helpman-Melitz-Rubinstein
HS	Harmonised System
i.i.d.	Identically and independently distributed
IAAE	International Association of Agricultural Economists
IATRC	International Agricultural Trade Research Consortium
ICTSD	International Centre for Trade and Sustainable Development
IDN	Indonesia
IM	Intensive margins of trade
IND	India
IRL	Ireland
ITA	Italy
ITJ	International Trade Journal
IV	Instrumental Variable
JAD	Journal of African Development
JAE	Journal of Agricultural Economics
JCM	Journal of Commodity Markets
JIE	Journal of International Economics

JITED	Journal of International Trade & Economic Development
JPN	Japan
KOR	Republic of Korea
LBY	Libya
MAR	Morocco
MEX	Mexico
MP	Marine Policy
MRA	Meta-Regression Analysis
MRL	Maximum Residue Level
n.a.	Not available
n.e.s.	Not elsewhere specified
n.s.	Not significant
NB	Negative Binomial
NE	Net exporter
NI	Net importer
NN	North-North
NN-NS	Trade from North
NN-SS	Horizontal trade
North	Developed economies
NS	North-South
NS-SN	Transversal trade
NTB	Non-Tariff Barrier
NTM	Non-Tariff Measure
NWP	New World Producers
NZL	New Zealand
OECD	Organisation for Economic Co-operation and Development
OWP	Old World Producers
PER	Peru
PPML	Poisson Pseudo-Maximum Likelihood
PRT	Portugal
PTA	Preferential Trade Agreement
RTA	Regional Trade Agreement
RUS	Russian Federation
RWE	Review of World Economics
SAEA	Southern Agricultural Economics Association
SGP	Singapore
SJR	Scimago Journal & Country Rank
SN	South-North
South	Developing economies
SPS	Sanitary and Phytosanitary Standard
SS	South-South
SS-SN	Trade from South
STC	Specific Trade Concern
SWE	Sweden
TBT	Technical Barrier to Trade
TE	Trade effect
TR	Trade routes
TRQ	Tariff Rate Quota
TUN	Tunisia
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
US	United States
USA	United States
WBER	World Bank Economic Review
WD	World Development
WE	World Economics
WP	Working Paper
WTO	World Trade Organisation
ZAF	South Africa
ZINB	Zero-Inflated Negative Binomial
ZIP	Zero-Inflated Poisson

1. Introduction

International agri-food markets can be politically sensitive and highly contentious (Anderson and Martin, 2005). The political sensitivity of agri-food trade is due to the complex dynamics among stakeholders—dynamics that are related to trade specialisations and comparative advantages (Martin, 2018). The frequent disputes in international negotiations are due to the high levels of policy intervention: trade distortions in agri-food sector are exceptional and highly controversial relative to those in other economic sectors (Trebilcock and Pue, 2015).

The recent period of relative openness to agri-food trade has helped to redistribute market shares from developed to developing countries and been accompanied by greater use by developing countries of policy interventions that formerly had been the sole domain of developed countries. Nevertheless, the *status quo* is still far from the *optimum* that could be achieved through negotiations (Bagwell and Staiger, 2011). The risk of not negotiating is to incur high levels of protection, which can garner strong domestic political support but be suboptimal at global level (Anderson and Nelgen, 2012; Ivanic and Martin, 2014). Long-lasting protection of domestic agri-food markets has created severe economic distortions at the national and international levels. The consequent delay in the development of agri-food sector has contributed to growing pressure for reforming agri-food policies. The crucial and complex set of negotiations at the World Trade Organisation (WTO) has attempted to liberalise trade and create a trade policy environment characterised by sustainable economic growth and less government intervention.

Multilateral trade agreements secured through WTO negotiations have increased opportunities for market access by lowering traditional barriers to trade (i.e. tariffs). However, growing concerns have been raised on the proliferation of non-tariff measures (NTMs) and their potential impacts on trade (Grant and Arita, 2017). NTMs, aimed at correcting market inefficiencies, may function as either trade catalysts or trade barriers (Xiong and Beghin, 2014), and non-tariff trade policies may have both winners and losers: some countries may benefit from liberalisation, while others may lose. Understanding the implications of changes in NTMs is thus highly relevant to economic wellbeing throughout the world.

Despite a large literature on NTMs and trade, there is limited research on how NTMs may have distorted trade patterns. Simply, how have NTMs influenced existing trade routes? Do NTMs have a role in determining and/or in strengthening new trade patterns? The contribution of this paper is three-fold. We provide insights into the potential correlations between trade and the level of policy interventions in agri-food sector, along with new evidence on the evolution of trade and NTMs over recent decades (Section 2). Second, we conduct a qualitative analysis on the sanitary and phytosanitary standards (SPSs) across countries, commodities, and types of measures, and we review empirical evidence on the impact of NTMs on agri-food trade and investigate the potential determinants of heterogeneity in estimates (Section 3). Third, we assess how SPSs affect trade growth, creation, and diversion in the agri-food sector. We use a large dataset on bilateral trade flows and SPSs covering the period 1990-2017, focusing on the most regulated agri-food products and on selected countries representing developed (North) and developing (South) countries. We adopt a gravity-based framework to model the interactions between trade and SPSs and draw conclusions on how North-North, North-South, South-North, and South-South trade patterns have evolved and how SPSs have influenced these changes (Section 4).

2. Trade and non-tariff measures in the agri-food sector: facts and figures

2.1. Agri-food trade: a global perspective

During the last two decades, global agri-food trade has undergone rapid change and a significant reshaping. The value of agri-food trade has progressively increased since the WTO agreements of the mid-1990s. Exports grew by 23% from 1995 to 2005 and again by 23% from 2005 to 2017; similarly, imports expanded by 30% from 1995 to 2005 and by 24% from 2005 to 2017. As a result, the world's total agri-food exports exceeded 600 billion US dollars (US$) in 2017, compared with less than US$500 billion in 1995 (UN Comtrade, 2018).

Developing countries in particular experienced a remarkable increase in their agri-food trade between 1995 and 2015 (Martin, 2018). Based on a set of 19 economies—6 developed (North) and 13 developing (South)—that account for more than three quarters of the world's gross domestic product (GDP),[1] we find that South-to-North (South-North) and South-South trade increased exponentially (from US$21 billion to US$4,230 billion), North-North trade became six times greater, and North-to-South trade (North-South) dectupled (table 1). Simply, trade from and to Southern countries is expanding very rapidly.

Table 1. Trade of selected agri-food products for selected North and South countries (in billions of U.S. dollars).

Origin country	Destination country					
	North		South		Total	
	1995	2015	1995	2015	1995	2015
North	556	3,200	279	2,850	835	6,050
South	10	1,660	11	2,570	21	4,230
Total	566	4,860	290	5,420	856	10,280

Source : Elaboration on UN Comtrade (2018).
Notes: Products included in these calculations are meat, fish, dairy products, vegetables, fruit, cereals, oilseeds, and preparations of meat and fish.

Rapid growth in the agri-food trade intensity of developing economies is a direct consequence of two determinants: economic globalisation and structural changes in the composition of agri-food trade (Henson et al., 2000). Globalisation has stimulated the development of global commodity chains and deepened economic integration (Disdier et al., 2015). Since the turn of the 21st century, developing economies have driven the development of global agri-food markets. These economies have become more export-oriented and modified the composition of their exports, shifting from traditional commodities (e.g. coffee, tea, sugar, cocoa) toward non-traditional, high-value commodities (e.g. fruit and vegetables, poultry, fish) (Henson and Loader, 2001).

The general increase in trade intensity is also due to the progressive process of trade liberalisation, as well as the provision of stricter standards to fulfill bilateral agreements (Disdier et al., 2015). A vast majority of countries have sought to improve their market access though preferential and regional trade agreements. In fact, while multilateral negotiations have stalled, many trade agreements that are not multilateral have entered into force (fig. 1). Over the last two decades, the number of new agreements notified to the WTO has expanded considerably:

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[1] The 6 developed economies are Australia, Canada, the European Union (EU), New Zealand, Russia, and the United States (US); the 13 developing economies are Argentina, Bolivia, Brazil, China, Congo, Egypt, India, Indonesia, Libya, Morocco, Peru, South Africa, and Tunisia. Throughout the paper, we use the classification of developed and developing countries offered by United Nations (2017), except for Russia, which is listed by the United Nations as an economy in transition, but which we treat as a developed country for the purposes of this paper.

in 2017, the total number of trade agreements was 314 (compared to 96 in 2000), 90% of which were classified as regional trade agreements (RTAs) and the others as preferential trade agreements (PTAs).

Trade agreements may facilitate market access by lowering tariffs and by providing other market access concessions (Grant and Lambert, 2008; OECD, 2015). However, such agreements tend to have a dual effect on trade: on the one hand, they foster intra-bloc trade; on the other hand, they may lead to trade diversion from developing countries (Koo et al., 2006; Lambert and McKoy, 2009; Sun and Reed, 2010).

Figure 1. Global trade agreements by year of entry into force, 1990-2017.
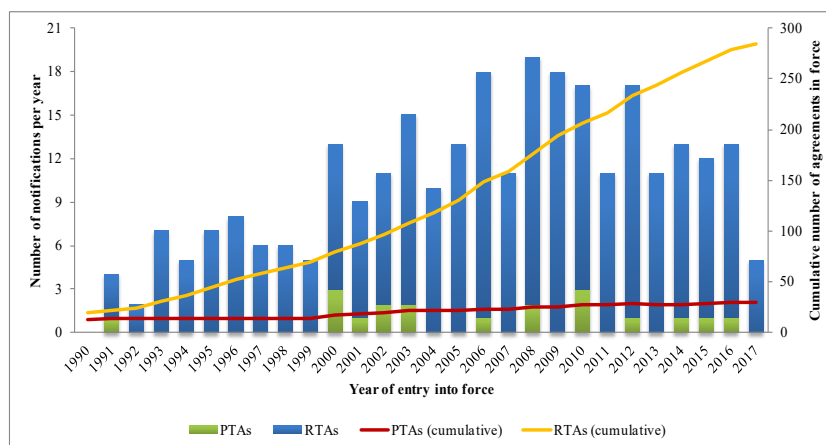
Notes: PTA=Preferential Trade Agreements. RTA=Regional Trade Agreements.

Source: Elaboration on RTA-IS (2018) and WTO (2018).

Most countries are parties to at least one RTA. In our set of 19 countries, 13 (65%) participate in RTAs. RTAs are more frequent among countries with similar levels of economic development: Australia and New Zealand have had an RTA since 1983, while in 1994, the United States (US) and Canada folded their existing RTA from 1989 into an RTA that also involves Mexico (not in our set of 19). All four of the Latin American countries in our set of 19 participate in RTAs, and China has trade agreements with New Zealand (2008), Indonesia (2009), Peru (2010), and Australia (2015), as well as with other countries not in the set of 19. In contrast, Russia and the African countries in our set of 19 have no RTAs in force (except for Morocco, which implemented an RTA with the US in 2006). Several RTAs involve countries with different levels of economic development: examples include Peru-US (2009), Peru-Canada (2010), Peru-European Union (EU) (2013), and Indonesia with Australia and New Zealand (2010).

From 1990 to 2017, the average value of agri-food trade was greater among countries belonging to RTAs than among countries with no RTAs in place (US$266 million versus US$79 million) (UN Comtrade, 2018). Moreover, agri-food trade values among the parties of an RTA tend to increase after the RTA enters into force (exceptions to this pattern include Indonesia's trade with China, Australia, and New Zealand and Canada-Peru trade). Latin American countries are particularly favoured by RTAs, with agri-food trade values up to six times larger when RTAs are in place. In addition, the number of SPSs during 1990-2017 was lower among countries within RTAs (on average 1 SPS within RTAs compared to 2 with no RTAs) (UNCTAD, 2017). For example, the number of SPSs between the US and Australia and between the US and Morocco decreased by 20% since the implementation of RTAs between those country pairs; a similar dynamic is found for the US and Peru (25% decrease) as well as for Indonesia and Australia and for New Zealand and China (more than 40% in all cases).

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2.2. *Policy instruments in agri-food trade*

Changes in global agri-food trade have stimulated a reorganisation of policy interventions. While it is true that the WTO contributed to lower tariffs and foster trade, the number of border measures remains high.

Despite efforts to reduce tariff levels, the level of intervention has remained high due to a large number of non-tariff instruments which has increased over time. The NTMs are alternatives to tariffs and are capable of shaping trade flows (Arita et al., 2017); their growing (ab)use has led to a less transparent trade policy environment (Fernandes et al., 2017).

The effects of NTMs are not clear. A dated view depicts NTMs as 'non-tariff barriers' (NTBs) and emphasises their protectionist scopes (*cfr.* quotas, export restraints). More recently, economists and policymakers have preferred the term 'non-tariff measures' which conveys a wider and more diverse set of meanings: the NTMs may either hamper or facilitate trade (Grant and Arita, 2017). In fact, the United Nations Conference on Trade and Development (UNCTAD) defines NTMs as "policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2012: 1). NTMs may play a corrective role: they may reduce asymmetric information, mitigate risks in consumption and improve the sustainability of eco-systems, or influence the competition and the decision to import or export.

The number of NTMs on agri-food products has increased tremendously at a global level, from 1.09 million in 2005 to 3.41 million in 2015 (UNCTAD, 2017). This increase is possibly due in part to the 2007-08 food price crisis, as several governments responded to higher agricultural commodity prices by imposing export restrictions and import duties aiming at insulating domestic markets from international price volatility (Greenville, 2015). Often, these measures would have asymmetric effects (Anderson and Nelgen, 2011; Santeramo et al., 2018). The gain in terms of reduced volatility in domestic agricultural markets would come at the expense of increased volatility in the international market, mainly affecting countries more open to trade (Ivanic and Martin, 2014; Santeramo and Lamonaca, 2019a).

SPSs, the most commonly adopted NTMs, grew by 178% over the same period at a global level (2005-15) (fig. 2). SPSs have a significant economic impact on agri-food trade and are often subject to negotiations (Ghodsi et al., 2017; Grant and Arita, 2017). SPSs cover a variety of issues:

- Protection of human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms in their food;
- Protection of human life from plant- or animal-carried diseases;
- Protection of animal or plant life from pests, diseases, or disease-causing organisms;
- Prevention of damage to a country from the entry, establishment or spread of pests; and
- Protection of biodiversity (UNCTAD, 2012: 7).

SPSs tend to regulate trade of agri-food products that are perishable and vulnerable to disease or pests (Grant and Arita, 2017). The SPSs in effect worldwide are distributed unevenly across agri-food sectors: in descending order, fish (27%), meat (14%), vegetables (9%), dairy products (8%), preparations of meat and fish (8%), fruit (7%) (UNCTAD, 2017).[2]

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[2] We classify traded products using the internationally standardised system of names and codes called the Harmonised Commodity Description and Coding System—or the Harmonised System (HS), for short.

Figure 2. Policy interventions (1995-2015) and detail by type of nontariff measure (NTM)
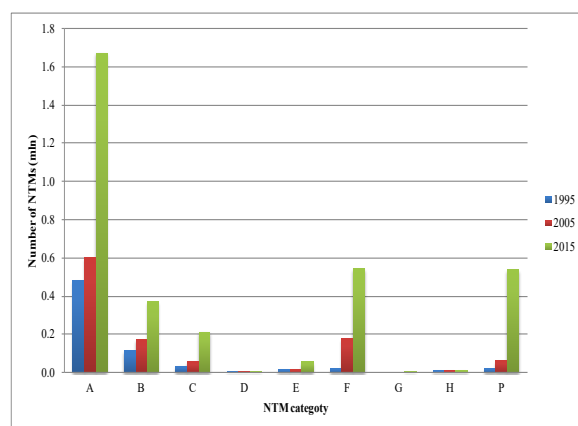
Source: elaboration on UNCTAD (2017).
Note: Categories of NTMs follow the convention in UNCTAD (2012): A = sanitary and phytosanitary standards (SPSs); B = technical barriers to trade (TBTs); C = pre-shipment inspections; D = contingent trade-protective measures; E = quantity-control measures; F = price-control measures; G = finance measures; H = measures affecting competition; and P = export-related measures.

The most commonly implemented SPSs at global level are certification requirements (A830, 18%), special authorisation requirements (A140, 17%), tolerance limits for residues of or contamination by certain (non-microbiological) substances (A210, 10%), testing requirements (A820, 8%), geographic restrictions on eligibility (A120, 7%), packaging (A330, 6%), and labelling requirements (A310, 4%) (UNCTAD, 2017).

Considering the set of 19 economies, the number of implemented SPSs more than tripled (from about 33,000 to 126,000) between 1995 and 2015 (table 2). The SPSs of developed countries have doubled, while those of developing countries has increased exponentially, from 800 to about 66,000. The increase is leading to a less transparent regulatory environment (Jongwanich, 2009). The number of implementing countries has more than doubled since 1995. The US was responsible for 96%, while China (2%), New Zealand (2%), Brazil and Argentina (1%) had a lower contribution; in 2015, the US and Indonesia were the leading implementing countries (respectively 35% and 32%), followed by New Zealand (10%) and Brazil (8%) (UNCTAD, 2017).

Table 2. Number of SPSs implemented on selected agri-food products for North and South countries, 1995 and 2015.

| Implementing country | Affected country | | | | | |
| | North | | South | | Total | |
	1995	2015	1995	2015	1995	2015
North	14,025	24,044	18,622	36,455	32,647	60,499
South	151	29,067	649	36,696	800	65,763
Total	14,176	53,111	19,271	73,151	33,447	126,262

Source: UNCTAD (2017).
Note: Selected products are meat, fish, dairy products, vegetables, fruit, cereals, oilseeds, preparations of meat and fish.

Between 1995 and 2015, the number of implemented SPSs grew from roughly 33,000 to 126,000: it approximately doubled in China (from 684 to 1,247) and the US (from 32,096 to 43,982), and it expanded exponentially in Argentina (from 4 to 915), Brazil (from 112 to 10,207), and New Zealand (from 551 to 12,947). Notably, none of the African countries (Congo, Egypt, Libya, Morocco, Tunisia) in our set of 19 countries had implemented SPSs in either 1995 or 2015. The same is true for the EU, Australia, and India (UNCTAD, 2017). A plausible explanation of the lack of imposition in African countries and in India is that the implementation

of SPSs requires adequate financial and technical resources. Also, sometimes, developing countries do not consider the implementation of SPSs a way to establish a dynamic trade environment in their domestic economies (Athukorala and Jayasuriya, 2003). Moreover, some developing countries may be reluctant to implement their own SPSs because their agri-food exports have been adversely affected by sanitary or phytosanitary crises. For instance, in 1998, the EU banned fishery product imports from Kenya, Mozambique, Tanzania, and Uganda to safeguard EU consumers from the risk of cholera (Henson et al., 2000), and in 2000, the EU removed India from the list of approved countries for imports of egg powder, seafood products, and mango pulp due to high pesticide residues (Mehta and George, 2003). The challenges that some developing countries face in meeting foreign standards may reduce the probability that domestic standards are established in WTO consultations.

EU member states frequently use requirements for Maximum Residue Levels (MRLs) to ensure safe imports as an alternative to SPSs. For food and animal feed, the European Commission fixes MRLs considered to be legally tolerable. Requirements on MRLs may be assimilated by the SPS A200 on the tolerance limits for residues and the restricted use of certain substances in food and feed (UNCTAD, 2012). Australia follows a similar approach in adopting MRLs instead of SPSs. The imposition of MRLs by the EU and Australia is documented in multiple studies (e.g. Otsuki et al., 2001a,b; Wilson et al., 2003; Wilson and Otsuki, 2004; Chen et al., 2008; Disdier and Marette, 2010; Xiong and Beghin, 2011; Drogué and De Maria, 2012; Melo et al., 2014).

In our sample, countries that have increased or introduced SPSs have amplified their trade openness ratio.[3] In particular, we observe the greatest growth in the trade openness ratio between 1995 and 2015 for Bolivia (+20%), China (+13%), Argentina (+6%), and Peru (+4%); Canada and New Zealand are economies with the highest agricultural propensity.

From 1995 to 2015, the number of SPSs in effect is almost unchanged, except for the US, whose intensity of SPSs in effect (almost non-existent in 1995) was 4% in 2015, and Indonesia, for which the intensity of SPSs in effect decreased from 4% to 2% over the two decades. The number of implemented SPSs has been reduced for meat-based products (-41%) and vegetables (-36%) and has increased tremendously for fishery products (+2773%). In our sample, while in 1995, only Indonesia and Russia have been interested by SPSs on fishery products, in 2015, SPSs have been raised against all countries: the relevant growth in the intensity of SPSs on fishery products may be due to a general increase in trade openness ratio for this category. The intensity of SPSs for other products (i.e. dairy products, fruit, cereals, oilseeds, preparations of meat and fish) has remained stable (UN Comtrade, 2017; UNCTAD, 2017).

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[3] In line with Wacziarg (2001), the trade openness ratio is computed as the sum of domestic agri-food imports and exports compared to the annual GDP. Categories covered correspond to the following HS-2 chapters: meat (02), fish (03), dairy products (04), vegetables (07), fruit (08), cereals (10), oilseeds (12), preparations of meat and fish (16).

Figure 3. Number of SPSs by product category in 2016.
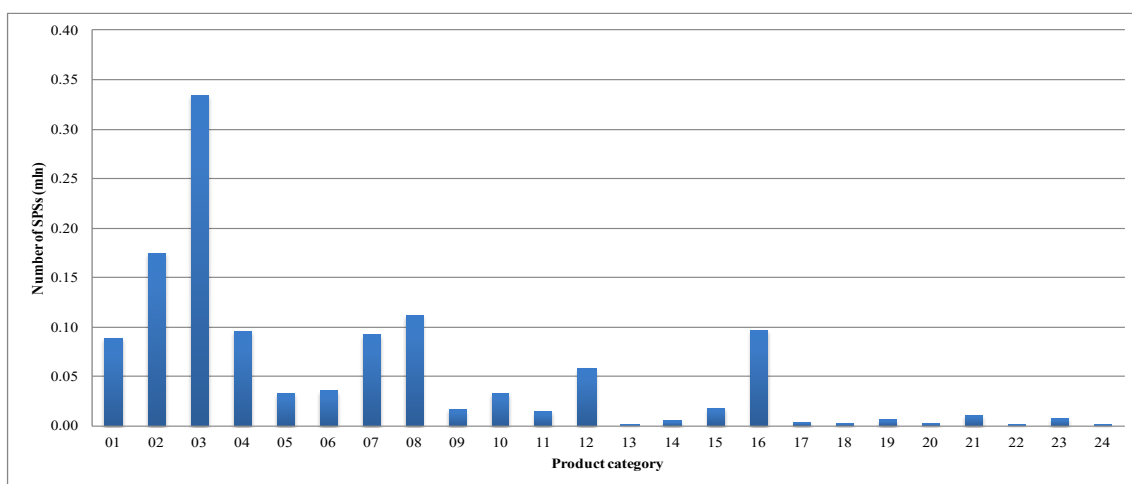
Source: elaboration on UNCTAD (2017).
Notes: Product categories correspond to HS-2 Chapter Headings: (01) Live animals; (02) Meat; (03) Fish; (04) Dairy produce; (05) Products of animal origin; (06) Live trees and other plants; (07) Vegetables; (08) Fruit; (09) Coffee, tea, mate and spices; (10) Cereals; (11) Products of the milling industry; (12) Oil seeds; (13) Lac; (14) Vegetable planting material; (15) Animal or vegetable fats and oils; (16) Preparations of meat, fish; (17) Sugars and sugar confectionery; (18) Cocoa and cocoa preparations; (19) Preparations of cereals, flour, starch or milk; (20) Preparations of vegetables, fruit.

Figure 4. Number of SPSs, by type of standard, 2016.
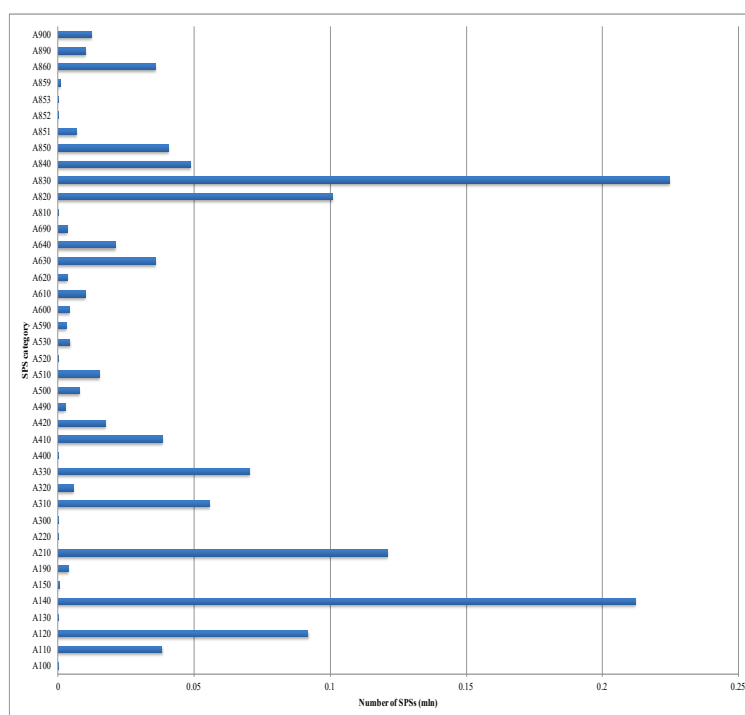
Source: Elaboration on UNCTAD (2017).
Notes: Classification of SPS types corresponds to that in UNCTAD (2012): (A1) Prohibitions/restrictions of imports for SPS reasons; (A2) Tolerance limits for residues and restricted use of substances; (A3) Labelling, Marking and Packaging requirements; (A4) Hygienic Requirements; (A5) Treatments for elimination of plant and animal pests and disease-causing organisms in the final product (e.g. Post-harvest treatment); (A6) Other Requirements on Production or Post-Production Processes; (A8) Conformity Assessment related to SPS; (A9) SPS Measures, not elsewhere specified.

3. On existing knowledge on trade effects of non-tariff measures

The proliferation of NTMs after the WTO's creation has resulted in a less transparent trade policy environment (Harvey, 1994; Fernandes et al., 2017) and spurred a great deal of research (e.g. Hooker and Caswell, 1999; Wilson and Otsuki, 2004; Dawson, 2006; Sheldon, 2006; Olper and Raimondi, 2008; Cioffi et al., 2011; Beckman and Arita, 2016). In particular, the number of studies on the trade effects of NTMs increased significantly—from 14 studies available in 2000 to 140 published studies through 2017. This upward trend parallels the upward trend in the number of NTMs imposed—from 1.09 million notified in 2000 to 4.35 million in 2017. However, the sign and magnitude of the estimated trade effects of measures (ETEMs) are not clear cut. Some issues deserve attention and, in particular, we pose the following questions: what is the prevailing effect of NTMs on agri-food trade? Do NTMs enhance or impede trade? Which factors influence the heterogeneity in ETEMs?

These issues have been partly investigated by Cipollina and Salvatici (2008), Li and Beghin (2012), Beghin et al. (2015), and Salvatici et al. (2017). Several reviews examine specific categories of NTMs or particular geographic areas. For example, Cipollina and Salvatici (2008) pay attention to trade policies implemented at the border, and Salvatici et al. (2017) focus on EU trade measures. The existing reviews tend to be qualitative analyses, with the exception of Li and Beghin (2012) who propose a meta-analysis to explain the causes of variation in estimated effects of technical measures on agri-food and manufacturing trade. By analysing a set of 27 papers that rely on gravity models, Li and Beghin show that some determinants (e.g. specific agri-food sectors, exclusion of multilateral resistance terms, proxies used for NTMs) are associated with trade-impeding effects of technical measures. Some issues, however, are still underinvestigated in their study. For instance, they do not consider the effects of the review process (a major driver in meta-analyses), the types of NTMs, the proxies used for NTMs, and the aggregation level at which a particular study is conducted.

We review empirical evidence on the impacts of NTMs on agri-food trade to conclude on potential determinants of heterogeneity in ETEMs. In order to complement previous studies, we analyse a larger set of more recent empirical research on the trade effects of NTMs and apply the theoretical arguments of meta-analyses (Stanley and Jarrell, 1989; Stanley, 2005; Stanley et al., 2008). We conclude on the effects of the types of NTMs, the proxies used for NTMs, the aggregation level at which the study is conducted, and the publication process.

3.1. The trade effect of non-tariff measures

The empirical literature on NTMs and trade provides mixed evidence. Several studies suggest that NTMs hamper trade (e.g. Peterson et al., 2013; Dal Bianco et al., 2016), while others conclude that they foster trade (e.g. Cardamone, 2011), and several studies offer mixed evidence (e.g. Xiong and Beghin, 2011; Beckman and Arita, 2016). Such heterogeneity may be explained by the diversity in empirical studies. Few studies provide a general assessment of the trade effects of NTMs: a remarkable case is Hoeckman and Nicita (2011), who suggest that NTMs are major frictions to agri-food trade. In contrast, most studies are either partial, region-specific, or focused on specific products. The heterogeneity is also due to a variety of methodological and empirical approaches: different proxies are used to measure NTMs, and different types of data and estimators are utililized. In addition, the effects of NTMs is often estimated as sector- and/or product-specific.

The trade effects of NTMs may also be geography-specific (e.g. Wilson and Otsuki, 2003; Chevassus-Lozza et al., 2008; Anders and Caswell, 2009; Disdier and Marette, 2010; Shepherd and Wilson, 2013). NTMs may have negative (e.g. Yue and Beghin, 2009) or positive effects (de Frahan and Vancauteren, 2006) on trade among developed countries. In contrast, NTMs tend to limit trade among developing countries (Melo et al., 2014).

In particular, Technical Barriers to Trade (TBTs) tend to be catalysts for trade (e.g. de Frahan and Vancauteren, 2006), while mixed evidence (e.g. Schlueter et al., 2009; Jayasinghe et al., 2010; Crivelli and Gröschl, 2016) is found for SPSs. The heterogeneity may be due to the peculiar nature of SPSs, which could have a positive or a negative impact, either of which could be substantial and significant (Schlueter et al., 2009: 1489). The existing literature indicates that MRLs tend to function as trade barriers (e.g. Otsuki et al., 2001 a, b; Chen et al., 2008; Ferro et al., 2015).

As for the use of different proxies for NTMs, the trade effects tend to be negative if standards are proxied by *ad valorem equivalent* (AVE) (e.g. Olper and Raimondi, 2008; Arita et al., 2017) or by frequency index and/or coverage ratio (e.g. Jongwanich, 2009; Fernandes et al., 2017). In contrast, if standards are proxied by dummy variables or count variables, the results can be positive (e.g. Cardamone, 2011; Shepherd and Wilson, 2013) or negative (e.g. Peterson et al., 2013; Dal Bianco et al., 2016).

3.2. A systematic review of empirical literature

Our systematic review of the literature follows the protocol suggested in Littell et al. (2008). We use several bibliographic databases to collect papers published from 1990 to 2017: Scopus, Web of Science, and JSTOR provided access to field and multidisciplinary journals; RePEc, IATRC, AgEcon Search, and Google Scholar allowed to cover grey literature[4] (i.e. working papers and conference proceedings); repositories of specific peer-reviewed journals and papers cross-references traced back further works. The search was carried out from June to August 2017.

Using keywords such as 'trade' and 'agri-food trade' in combination with other terms ('non-tariff measure/non-tariff barrier,' 'technical barrier to trade,' 'sanitary and phytosanitary standard,' 'maximum residue level,' and 'specific trade concern'), we identified 155 studies. Subsequently, each paper was reviewed in depth, so as to limit the analysis to papers that assess the trade effects of NTMs; we excluded theoretical studies and papers that do not provide comparable empirical results. The final sample includes 62 papers (47 published in peer-reviewed journals, and 15 from grey literature), 1,364 observations (point estimates of trade effects of measures, ETEMs) and 1,213 estimated t-statistics.

Heterogeneity in the ETEMs is likely due to the characteristics of the studies and to the publication process (Cipollina and Salvatici, 2010). The meta-analysis allows us to investigate such heterogeneity in estimates and to conclude on potential effects of the publication process (Glass, 1976). More precisely, the meta-analysis allows us to (i) isolate average effects, (ii) investigate the determinants of variability (without discriminating 'good' and 'bad' results), and

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[4] In line with other analyses of trade issues (e.g. Disdier and Head, 2008; Cipollina and Salvatici, 2010; Li and Beghin, 2012), we include working papers and conference proceedings to identify publication selection. A journal's prestige may be a source of publication bias (Santeramo and Shabnam, 2015). In order to avoid double counting, we include working papers and conference proceedings that do not correspond to revised versions published in peer-reviewed journals.

(iii) extract useful information from the existing literature (Havránek, 2010; Li and Beghin, 2012).

We regress the ETEMs on two sets of covariates which explain the magnitude of ETEMs and the publication process. The set of covariates related to the *magnitude of ETEMs* allows us to control for types of NTMs, proxies for NTMs, and the level of detail of the study. In particular, specific dummy variables account for types of measure (i.e. TBTs, SPSs, MRLs[5]). We also use dummy variables to identify countries that implement NTMs (reporters) and countries affected by NTMs (partners) and to classify reporters and partners as Northern (developed) or Southern (developing) countries.

Additional dummy variables are used to proxy the intensive and the extensive margins of the NTM. We assume that NTMs expressed as *ad valorem equivalents* (AVEs) proxy the intensive margins: AVEs capture the degree of protectionism of the NTMs (i.e. how much NTMs affect trade). NTMs modelled as dummy variables or indices (frequency indices, coverage ratios) are assumed to proxy the extensive margins of NTMs (e.g. existence or not of NTMs). We also use dummy variables to control for the level of product aggregation and the specific product category under investigation (both using HS codes).

A second set of covariates controls for potential *publication selection*. According to Stanley et al. (2008), the publication selection is a socioeconomic phenomenon that includes publication bias.[6] We use dummy variables to account for the prestige of the publication outlet and for grey literature: one dummy variable controls for papers published in top journals (ranked in the first quartile [Q1]) and one dummy accounts for working papers. Furthermore, we use a dummy variable to control for the presence of more than one article published by the same author.

We control for the adoption of fixed effects to account for multilateral trade resistance terms in gravity models and for the treatment of zero trade flows. The zero trade flows problem is a common issue in studies based on the gravity equation; 87% of the papers in our sample are based on the gravity model. We consider differences in estimation procedures: Tobit model, Heckman procedure, Poisson Pseudo-Maximum Likelihood (PPML) estimator, and other estimators (Zero-Inflated Poisson, ZIP, and Zero-Inflated Negative Binomial regressions, ZINB). The meta-regression analysis (MRA) consists of regressing t-statistics on the ETEMs:

$$\hat{t} = \alpha_0 + \alpha_1 \frac{1}{\hat{\sigma}} + \sum_{j=1}^{J} \beta_j \frac{X_j}{\hat{\sigma}} + \sum_{k=1}^{K} \gamma_k Z_k + \varepsilon \tag{1}$$

where the t-statistic of ETEMs ($\hat{t}$) depends on the precision of the estimates (i.e. the inverse of the estimated standard error, $\frac{1}{\hat{\sigma}}$), on J regressors related to the magnitude of ETEMs (X_j), and on K regressors related to potential publication selection (Z_k). In line with Stanley et al. (2008), we include variables (X_j) that are likely to influence the estimates but are uncorrelated with the likelihood of acceptance, as well as variables (Z_k) that may influence the likelihood of acceptance for publication but should not be informative on the estimates. The constant term (α_0) collects potential information on the publication selection that are not directly included in the model

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[5] Countries frequently define MRLs, as an alternative to SPSs, in order to ensure safe imports. The requirements on MRLs are not set in the WTO consultations, but they may be assimilated to the SPS A200 that sets the tolerance limits for residues and imposes a restricted use of certain substances in food and feed (UNCTAD, 2012). Due to these considerations, we distinguish SPSs and MRLs in separate categories.
[6] Publication bias may occur if there is a systematic preference in the discipline for a particular type of result (i.e. negative or positive estimated effect) (type I bias) and/or statistically significant results (type II bias) (Stanley, 2005). Stanley et al. (2008) suggest using estimated standard errors to control for the precision of estimates and to detect potential publication bias.

(Stanley and Jarrell, 1989). The error term (ε_i) is assumed to be independently and identically distributed (i.i.d.). We use a Multinomial Logit (MNL) model to explain positive/negative significance of ETEMs: the dependent variable is categorical (Y_{MNL}) and distinguishes the *i*-th ETEMs in negative (t-statistic below −1.96), not significant (t-statistic between −1.96 and 1.96), or positive (t-statistic above 1.96):

$$Y_{MNL} = \begin{cases} -1 \ if \ \hat{t}_i \leq -1.96 \\ 0 \ if \ -1.96 < \hat{t}_i < 1.96 \\ 1 \ if \ \hat{t}_i \geq 1.96 \end{cases} \tag{2}$$

A Probit model is adopted to explain the drivers of statistical significance, and a Tobit model is used to focus on the magnitude of the estimated t-statistics. The dependent variable of the Probit model is a dummy variable equal to 1 if the *i*-th ETEM is statistically significant (t-statistic lower than −1.96, or higher than 1.96), and 0 otherwise:

$$Y_{Probit} = \begin{cases} 1 \ if \ \hat{t}_i \leq -1.96 \ or \ \hat{t}_i \geq 1.96 \\ 0 \ otherwise \end{cases} \tag{3}$$

The dependent variable of the Tobit model is a continuous variable equal to the t-statistics of ETEMs ($\hat{t}$), if it is larger than the threshold value (1.96 in absolute value), and 0 otherwise. In line with Li and Beghin (2012), we use a robust estimator of the clustered error structure to estimate MNL, Probit, and Tobit models. We assume independence among clusters (i.e. papers) and dependence among observations within each cluster (i.e. ETEMs of the same paper).

3.3. Meta-Regression results

Our sample reflects the heterogeneity that is also observed in the literature. Papers supporting the 'standards as barriers' view are the majority (34 papers), while papers that conclude on the 'standards as catalysts' view are in limited number (3 papers). Twenty-one papers offer mixed evidence. Several studies contain multiple ETEMs: in order to keep important information, we include all available evidence (Jeppensen et al., 2002), rather than opting for the preferred estimate method, or for a synthesis of the estimates (Card and Krueger, 1995; Stanley, 2001; Rose and Stanley, 2005).

56% of the ETEMs (759 point estimates) are negative; 44% (605 point estimates) are non-negative (positive or zero). A majority of estimates (61%) are statistically significant, with 508 point estimates (37%) being negative and 325 point estimates (24%) being positive. The mean and median values are, respectively, -0.30 and -0.05 (confidence interval ranges from -3.33 to 2.73).

Table 3. Descriptive statistics of the estimated trade effects of measures (ETEMs).

ETEMs	Min	Max	Median	Mean	Std. Dev.	C.I.[a]	Obs.[b]
Total	-38.540	54.140	-0.048	-0.305	3.039	[-3.334; 2.734]	100%
Non-negative (positive or zero)	0.000	54.140	0.280	1.031	2.966	[-1.935; 3.997]	44%
Negative	-0.001	-38.540	-0.456	-1.37	2.653	[-4.023; 1.283]	56%
Significant	-38.540	18.105	-0.160	-0.598	3.151	[-3.749; 2.553]	61%
Significant non-negative (positive or zero)	0.000	18.105	0.580	1.263	2.296	[-1.033; 3.559]	24%
Significant negative	-38.540	-0.004	-0.734	-1.789	3.047	[-4.836; 1.258]	37%
Not significant	-12.920	54.140	0.004	0.155	2.795	[-2.640; 2.950]	39%

Notes: In the sample, only two observations are equal to zero.
[a] Confidence interval (C.I.) ranges between mean minus and plus standard deviation.
[b] Percentages computed on the total number of observations (1,364).

Figure 5 presents the distribution (boxplots) and the kernel densities of total, positive, and negative ETEMs[7]: half of the statistically significant ETEMs (680 observations out of 1,364) range between median values of (statistically significant) negative ($Me_{Neg.}$ = -0.42) and of (statistically significant) positive ($Me_{Pos.}$ = 0.34) observations (fig. 5, panel (i)). The distribution of total ETEMs is bimodal with one negative peak ($Mo_{Neg.}$ = -0.21) and one positive peak ($Mo_{Pos.}$ = 0.02). Negative and positive ETEMs are almost equally dispersed (the standard deviations of negative, $\sigma_{Neg.}$ = 2.65, and positive ETEMs, $\sigma_{Pos.}$ = 2.97 are close) (fig. 5, panel (ii)).

Figure 5. Estimated trade effect of measures (ETEMs) arranged by direction.
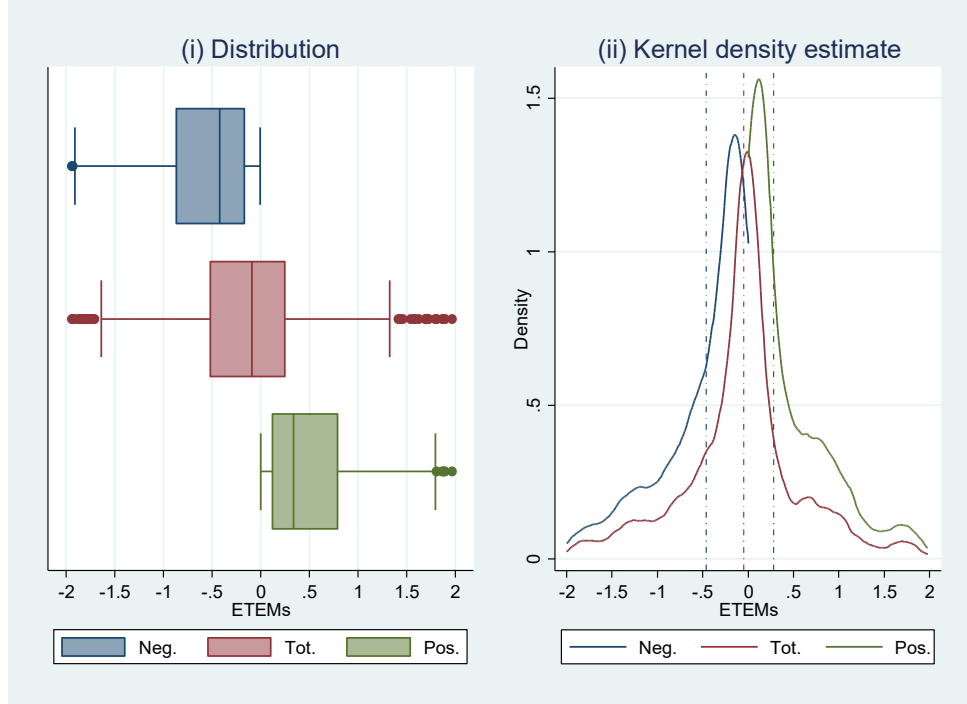
Notes: In panel (i), distributions of ETEMs are on statistically significant observations within the 10th and the 95th percentiles. Horizontal lines within boxes are median values (Me) (i.e. $Me_{Neg.}$ = -0.42, $Me_{Tot.}$ = -0.16, $Me_{Pos.}$ = 0.34). In panel (ii), the estimated densities for ETEMs are computed removing observations which exceed the 10th and the 95th percentiles. Dashed lines are median values (Me) computed on total observations (i.e. $Me_{Tot.}$ = -0.05, $Me_{Pos.}$ = 0.28, $Me_{Neg.}$ = -0.46).

Several variables seem correlated with the magnitude and direction of NTMs' trade effects (e.g. geo-economic areas, type of NTMs). Figure 6 shows that the ETEMs differ across geo-economic areas. Papers that investigate North-North or North-South trade (40 papers, 822 point estimates) are in larger number than papers that analyse South-North or South-South trade (3 papers, 76 point estimates) (fig. 6, panel (i)). The variability of ETEMs across papers that consider North-North (σ_{N-N} = 3.19) or North-South (σ_{N-S} = 4.17) trade is larger than forf papers on South-South trade (σ_{S-S} = 0.68). However, the median ETEM is lower for North-South trade (Me_{N-S} = -0.10) than for North-North trade (Me_{N-N} = -0.01) (fig. 6, panel (ii)).

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[7] The distribution and kernel density estimated refers to a subsample which ranges between the 10th and the 95th percentiles.

Figure 6. Estimated trade effect of measures (ETEMs) arranged by geo-economic areas.
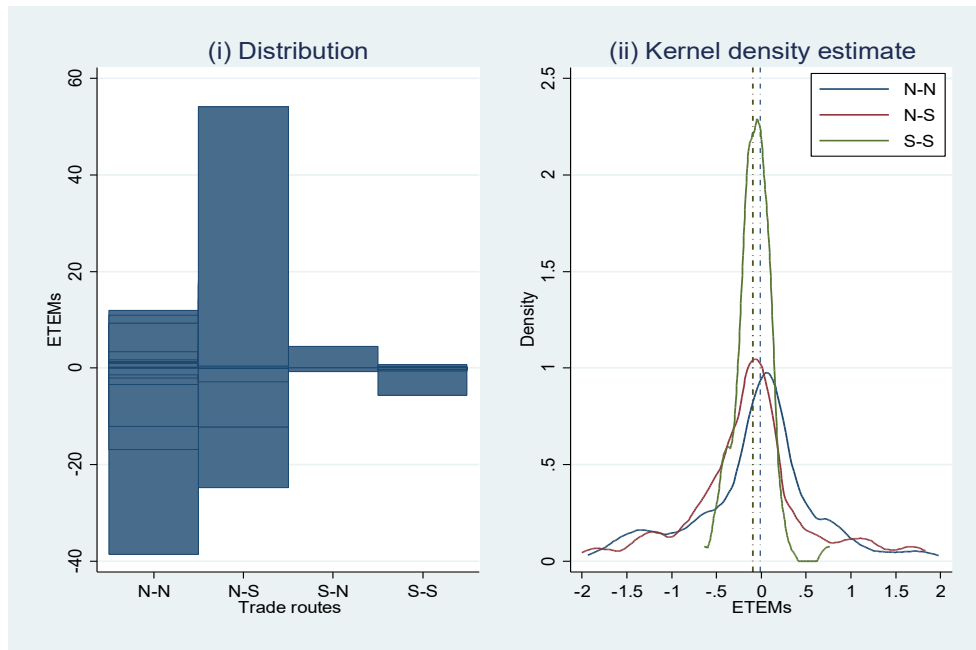
Notes: Geo-economic areas are as follows: N-N stands for 'North-North', N-S stands for 'North-South', S-N stands for 'South-North', S-S stands for 'South-South', where the former are countries imposing NTMs (reporters) and the latter are countries affected by NTMs (partners). Reporters and partners are classified into North (Developed Economies) and South (Developing Economies and Economies in transition), according to the country classification proposed by the United Nations (2017). In panel (ii), the estimated densities for ETEMs are computed removing observations which exceed the 10th and the 95th percentiles. Dashed lines are median values (Me) computed on total observations (i.e. $Me_{Tot.}$ = -0.05, Me_{N-N} = -0.01, Me_{N-S} = -0.10, Me_{S-S} = -0.09). Kernel density estimate for S-S is omitted because there are only two observations for ETEMs.

The ETEMs differ also by type of measure (fig. 7). A majority of papers focus on measures aiming at protecting human health (17 papers on SPSs and 25 papers on MRLs: 504 point estimates), while several studies (15 papers, for 362 point estimates) report evidence for NTMs not involved in specific categories (such as TBTs, SPSs, MRLs, or Specific Trade Concerns, STCs[8]): these cases (grouped under the tag 'Other') show a large heterogeneity in estimates, ranging from more than 50 to less than minus 15 (fig. 7, panel (i)). The variabilities of ETEMs for papers that analyse different types of NTMs are similar (σ_{TBT} = 3.51, σ_{SPS} = 3.66, σ_{Other} = 3.65); an exception to this pattern is the papers on MRLs, for which the variability is rather low (σ_{MRL} = 2.20). While the median values of ETEMs associated with TBTs and MRLs are close to zero (Me_{TBT} = 0.01, Me_{MRL} = 0.02), the median for SPSs is negative (Me_{SPS} = -0.11) (fig. 7, panel (ii)).

We compare the results of the MNL, Probit, and Tobit models. For TBTs, we found a negative coefficient in the MNL model and a positive coefficient in the Tobit model: there is a tendency for negative effects on trade. As for SPSs, the effect on trade is positive and larger in magnitude. Our findings expand the evidence provided by Li and Beghin (2012): we disentangle the effects of TBTs and SPSs and show that MRLs are associated with positive (and significant) ETEMs.

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8 Studies based on STCs, to concerns about SPS measures maintained by one or more WTO members, are particularly relevant and complement the evidence provided using UNCTAD data on SPSs (cfr. Grant and Arita, 2017).

Figure 7. Estimated trade effects of measures (ETEMs) by type of measure.
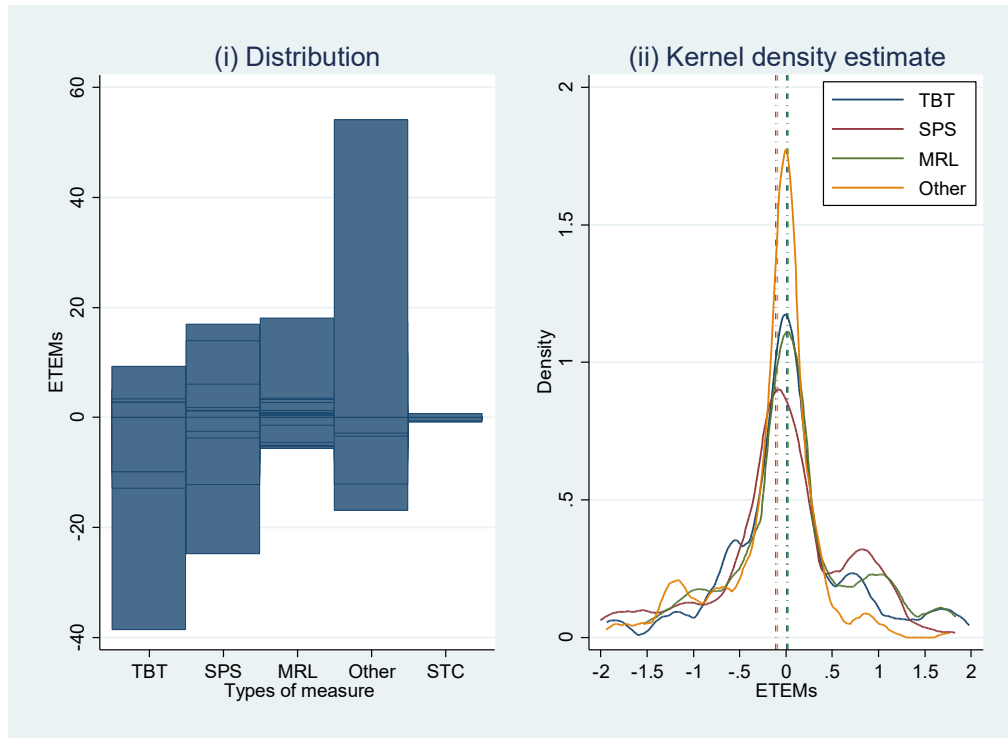
Notes: TBT = technical barrier to trade. SPS = sanitary and phytosanitary standard. MRL = maximum residue level. STC = specific trade concern. Other = measures not involved in other categories (e.g. quality and quantity control measures, Hazard Analysis and Critical Control Points (HACCP), private standards, voluntary standards). For the densities presented in panel (ii), observations exceeding the 10th and 95th percentiles were removed. Dashed lines are median values (Me) computed on total observations (i.e. $Me_{Tot.}$ = -0.05, Me_{TBT} = 0.01, Me_{SPS} = -0.11, Me_{MRL} = 0.02, Me_{Other} = -0.09). Kernel density estimate for STC is omitted because only 24 ETEMs were observed.

We found positive coefficients for North-North in the Probit model and negative coefficients for North-South in the Probit and MNL models: the ETEMs are significantly different from zero across countries with similar levels of economic development; the opposite is true for NTMs implemented by a developed country against a developing country. As in the Tobit model, where ETEMs are positive, ETEMs tend to be lower for measures implemented by developed against developing countries and greater for measures among countries with similar levels of economic development. These findings are in line with Li and Beghin (2012: 507): "when the NTM is a SPS policy regulating agri-food exports from a developing exporter to a developed importer, the probability to observe a trade impeding effect increases substantially." The Probit model shows positive coefficients for AVE, 'dummy', and 'index' (*cfr*. Section 3.2): with AVE, dummy variables, and the frequency index/coverage ratio, the ETEMs are non-zero. The variable 'HS-4 digit' is positive in the Probit model: the higher the data disaggregation, the higher the likelihood of reporting significant estimates. If ETEMs are negative, the trade effects are higher.

As for product-specific categories, we found positive (negative) significant coefficients for meat (dairy) in the Probit and MNL models: the likelihood of significant ETEMs increases (decreases), and the probability of negative significant ETEMs is larger (smaller) for meat (dairy). For oilseeds and oleaginous fruits and/or for animal or vegetable fats and oils, the estimated t-statistics tend to be higher. In line with Li and Beghin (2012), technical measures are not likely to be trade-enhancing for agriculture and processed food products (e.g. meat and dairy products), but that this is not always true (e.g. for the other products under investigation).

The prestige of the publication outlet is negatively correlated with the statistical significance of ETEMs for peer-reviewed journals and working papers. ETEMs tend not to be significant in working papers. Conversely, the studies published in top journals (Q1) tend to show statistically significant results. The variable 'authors' is positive in the Probit and MNL models: papers co-authored by experienced scholars show statistically significant ETEMs. Havránek (2010: 254) argues the authorship helps to explain the direction and magnitude of estimates.

The country-pair fixed effect is positive in the Probit and MNL models: controlling for fixed effects correlates with statistically significant ETEMs. The likelihood of significant ETEMs is 5.58 (3.82) times higher for negative (positive) estimates. Li and Beghin (2012) pointed out that estimates on the effects of technical measures are influenced by the use of multilateral trade resistance terms. We show that controlling for product-specific (or sector/industry-specific) fixed effects decreases the likelihood of significant and positive ETEMs; controlling for time fixed effects does not influence statistical significance. The treatment of zero trade flows increases the probability of negative significant ETEMs. Li and Beghin (2012: 507) argue that "t-values are more spread out in the negative range when zero trade is treated."

Table 4. Summary of findings on the estimated trade effects of measures (ETEMs).

Covariates	Significant ETEMs	Negative significant ETEMs	Positive significant ETEMs
Q1	Not significant	Not significant	Negative
Working paper	Negative	Not significant	Negative
Authors	Positive	Positive	Positive
Country-pair fixed effect	Positive	Positive	Positive
Time fixed effect	Not significant	Not significant	Not significant
Product fixed effect	Not significant	Not significant	Negative
Zero trade	Not significant	Positive	Not significant
North-North	Positive	Not significant	Not significant
North-South	Negative	Negative	Negative
TBT	Not significant	Negative	Not significant
SPS	Positive	Not significant	Positive
MRL	Not significant	Not significant	Positive
AVE	Positive	Positive	Positive
Dummy variable	Positive	Positive	Not significant
Index	Positive	Not significant	Not significant
HS-2digit	Not significant	Not significant	Not significant
HS-4digit	Positive	Not significant	Not significant
Meat	Positive	Positive	Not significant
Dairy	Negative	Negative	Not significant
Cereal	Not significant	Not significant	Not significant
Oilseed	Not significant	Not significant	Not significant
F&O	Not significant	Not significant	Not significant
Beverage	Not significant	Not significant	Not significant

Numerous variables contribute to explain the heterogeneity in ETEMs (table 4)[9]: the likelihood of having significant estimates reduces with working paper, North-South, dairy, but increases with authors, country-pair fixed effect, North-North, SPS, AVE, dummy variable, index, HS-4 digits, and meat. The probability of estimating trade-impeding effects is boosted by authors, country-pair fixed effect, zero trade, AVE, dummy variable, and meat, and hampered by North-

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[9] In a sensitivity analysis, we controlled for WTO specific trade concerns and for bilateral versus multilateral measures. We omitted these variables from the model due to potential problem of collinearity and the irrelevance of results from a statistical perspective.

South, TBT, and dairy. The likelihood of estimating trade-enhancing effects may be intensified by authors, country-pair fixed effect, SPS, MRL, and AVE, or limited by Q1, working paper, North-South.

3.4. A focus on the effects of non-tariff measures on African agri-food trade

Since the mid-1990s, the agri-food trade of the developing economies has grown faster than that of the developed economies (Martin, 2018). Emblematic is the case of African countries, whose agri-food exports exponentially expanded during 1995-2013 (from US$8.5 billion to US$34.5 billion) and then suffered a setback (-34% in 2016) (UN Comtrade, 2017).

The rapid growth in the agri-food exports of developing economies, and of African countries in particular, may be a direct consequence of two determinants: (i) economic globalisation, which has stimulated the development of global commodity chains; and (ii) structural changes in the composition of agri-food trade, which has moved from traditional commodities (e.g. coffee, tea, sugar, cocoa) to non-traditional, high value commodities (e.g. fruit and vegetables, poultry, fish) (Henson et al., 2000). African economies have became more export-oriented, with substantial variations in the composition of exports: for instance, between 1995 and 2016, exports doubled for seafood products and vegetables and dectupled for meat, while traditional exports have declined (-43% for coffee and tea, -33% for cocoa) (UN Comtrade, 2017).

Integration of African countries in the world trading system strongly depends on opportunities for market access at favourable conditions (i.e. lower trade costs) (Henson and Loader, 2001). Border-related trade costs, in and of themselves high for agri-food commodities, appear to be vastly greater for Africa (Porteous, 2017). Although multilateral trade liberalisation through the WTO has increased opportunities for market access, the concurrent tightening of non-tariff trade policies may be particularly challenging for African countries (Nimenya et al., 2012). NTMs may undermine the comparative advantage of these countries in agri-food products, frequently due to the lack of adequate financial and technical capacity to comply with changing, and more stringent, standards (Jaffee and Henson, 2004; Martin, 2018). However, once standards have been met, the opportunity to upgrade quality and to boost export performances increases (Athukorala and Jayasuriya, 2003; Jongwanich, 2009).

Several studies have investigated the trade impact of NTMs on the African agri-food sector (e.g., Henson et al., 2000; Henson and Loader, 2001; Otsuki et al., 2001a, b; Wilson and Otsuki, 2004; Anders and Caswell, 2009; Jongwanich, 2009; Xiong and Beghin, 2011; Nimenya et al., 2012; Shepherd and Wilson, 2013). However, the vast majority of such studies are product-, country-, or NTM-specific. The peculiarity of the existing literature makes it difficult to form an overall view on the issue. We systematically review empirical evidence on the impact of NTMs on African agri-food trade and investigate the potential determinants of heterogeneity in estimates. In particular, we detect how the effects of NTMs on African trade are influenced by a wide set of determinants related to types of NTMs, products under investigation, methodological approaches, and publication process. A comparison between findings from empirical literature and evidence on NTMs and trade allows us to shed light on unexplored research areas.

We review a set of econometric studies of the effects of NTMs on African agri-food trade. From the full sample of empirical studies, we select 19 papers (14 published in peer-reviewed journals, 5 from grey literature) related to African countries: the sample has 225 observations (point

estimates of trade effects of measures, ETEMs) and 210 estimated t-statistics.[10] We collect information on publication (i.e. author(s), year, and outlet of publication), details of the study (i.e. countries involved in the analysis, product categories and types of measures under investigation), and overall conclusions on the trade effects of NTMs.

To evaluate these data, we compute descriptive statistics and perform a graphical analysis. In particular, we use boxplots and kernel density estimates to compare the distributions of specific sub-samples and arrange the estimated coefficients according to the direction of ETEMs (positive or negative), the statistical significance, the type of measure investigated (e.g. SPSs, MRLs). In addition, we compare positive and negative distributions of (significant) ETEMs. The rationale of the test is that the larger the deviation of Mo^+ from Mo^-, the larger the differences between the distributions of positive significant and negative significant ETEMs.

Ambiguity characterises the empirical evidence on NTMs and African trade. Several factors may help to explain heterogeneity in the empirical evidence: publication process, methodological issues, and level of details of the study. As for the main effect of NTMs on African trade, the 'standards as catalyst' and 'standards as barriers' points of view coexist within the sample: some studies highlight that NTMs hinder trade (Otsuki et al., 2001a, b; Wilson et al., 2003; Gebrehiwet et al., 2007; Scheepers et al., 2007; Disdier et al., 2008a; Anders and Caswell, 2009; Jongwanich, 2009; Drogué and De Maria, 2012; Kareem et al., 2015), while others provide mixed evidence (Wilson and Otsuki, 2004; Xiong and Beghin, 2011; Shepherd and Wilson, 2013; Kareem, 2014a, b, c; Kareem, 2016a, b, c). However, the trade-impeding nature of NTMs prevails in the ETEMs.

Table 5. Descriptive statistics of ETEMs: detail on direction of the effect and statistical significance.

ETEMs	Min		Max	Mode	Median	Mean	Std. Dev.	C.I.[a]	Obs.[b]
Total	-12.16		54.14	-0.02	-0.04	0.39	4.33	[-3.94; 4.73]	100%
Positive	0.40	[c]	54.14	0.05	0.51	1.97	6.04	[-4.06; 8.01]	43%
Negative	-12.16		-0.01	-0.02	-0.39	-0.79	1.59	[-2.38; 0.81]	57%
Significant	-12.16		18.11	-0.34	-0.11	0.28	3.28	[-3.00; 3.56]	46%
Significant positive	2.67	[c]	18.11	1.11	1.14	2.25	3.52	[-1.27; 5.78]	19%
Significant negative	-12.16		-0.02	-0.34	-0.68	-1.17	2.17	[-3.34; 1.00]	27%
Not significant	-2.85		54.14	-0.02	-0.02	0.49	5.08	[-4.59; 5.57]	54%

[a] Confidence interval (C.I.) ranges between mean minus and plus standard deviation.
[b] Percentages computed on the total number of observations (225).
[c] The magnitude of ETEMs are of the order of 10^{-14}.

Descriptive statistics show that 57% of ETEMs (129 point estimates) are negative, and 43% (96 point estimates) are positive (table 5). Less than half (46%) of the ETEMs are statistically significant, of which 27% (60 out of 225 point estimates) are negative and 19% (44 out of 225 point estimates) are positive. The mean and median values of (total) ETEMs are, respectively, 0.39 and -0.04, with a confidence interval ranging from -3.94 to 4.73. The total variability within observations (point estimates) is marked (4.33), driven by the higher dispersion of positive ETEMs (6.04) compared to negative ones (1.59). The distributions of positive and negative significant ETEMs are unimodal (Mo$_{Pos.}$ = 1.11, Mo$_{Neg.}$ = -0.34). If we run a test to compare the modes of positive and negative distributions of (significant) ETEMs[11], we find that differences

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[10] We have 15 missing values in the estimated t-statistics because some papers do not report standards errors or t-values.
[11] The test is computed by comparing, with the variability of total (significant) ETEMs, the difference between modes of the distributions of positive and negative (significant) ETEMs: $t = Mo^+ - Mo^-/\sigma = (1.11 - (-0.34))/3.28 = 0.44$. The value of the test is highly lower than the threshold value for the statistical significance (|1.96|), thus we reject H_0 in favour of H_1.

(statistically) are neither large nor significant, but (economically) they support opposite hypotheses (i.e. catalyst and barrier).

Figure 8 presents the distribution (boxplots) and kernel densities of total, positive, and negative ETEMs. The boxplots show the distributions of statistically significant ETEMs: we find that total significant ETEMs, approximately included between the first and the third quartiles (104 out of 225-point estimates), ranges between median values of (significant) negative ($Me_{Neg.}$ = -0.56) and of (significant) positive ($Me_{Pos.}$ = 1.07) observations (fig. 8, panel (i)). Also, the kernel densities (referring to either significant or not significant ETEMs) highlight differences between distributions: negative ETEMs are less dispersed than positive ETEMs (in terms of standard deviations of negative, $\sigma_{Neg.}$=1.59, and positive ETEMs, $\sigma_{Pos.}$=6.04) (fig. 8).

The global effect of NTMs does not capture the discrepancy between negative and positive estimates: negative estimates are more accurate and closer to zero; positive estimates are more dispersed. The distribution of total estimates smoothens the higher variability of positive estimates but also assumes a trend more erratic compared to negative estimates. The mixed evidence found in the literature and the high variability of estimates may be partly explained by the large heterogeneity in empirical studies (in terms of publication process, analysed countries, methodological approaches, products under investigation, and types of NTMs).

Ten out of the 19 papers are co-authored by academics who had already published research on the same issue. Experienced scholars tend to report similar results across papers. Otsuki et al. (2001a, b) evaluate the implication of Aflatoxin standards for African exports, respectively on groundnuts and on fruit, vegetables, and cereals. Wilson et al. (2003) examine the effect of food safety standards on beef trade; they find a trade-impeding effect, substantial enough to cause a remarkable loss of export revenue in African countries. Other studies confirm that experienced authorship helps to explain the direction of estimates (Havránek, 2010: 254).

Figure 8. ETEMs arranged by direction.
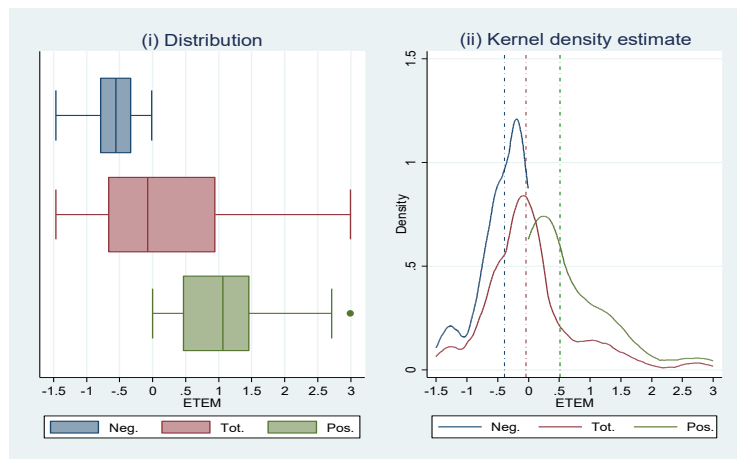
Notes: In panel (i), the distributions of ETEMs are on statistically significant observations within the 5th and 95th percentiles. Horizontal lines are median values (Me) (i.e., $Me_{Neg.}$ = -0.56, $Me_{Tot.}$ = -0.08, $Me_{Pos.}$ = 1.07). In panel (ii), the densities are computed on observations between the 5th and 95th percentiles. Dashed lines are median values (Me) on full sample (i.e., $Me_{Tot.}$ = -0.04, $Me_{Pos.}$ = 0.51, $Me_{Neg.}$ = -0.39).

The majority of the studies are unidirectional: they investigate the trade effects of NTMs implemented by developed countries against African countries. The few exceptions to this pattern are Wilson et al. (2003) and Wilson and Otsuki (2004), who consider NTMs implemented by Japan (and other developed countries), and Drogué and De Maria (2012), who investigate

the effects of bilateral NTMs among Argentina, Australia, Brazil, Canada, Chile, China, Japan, Korea, Mexico, New Zealand, Russia, South Africa, the US, the EU. We find that the countries implementing NTMs (reporters) that appear with higher frequency in empirical investigations are the EU (in 16 out of 19 studies), the US (4 of 19), and Canada and New Zealand (each with 3 of 19). The predominance of studies that investigate EU-Africa trading relationships is probably due to the relevance of the European market as a preferential outlet for African exports since the colonial period of the 1800s. Analysing data on NTMs, we find that 10 countries are responsible for 96% of global measures set against African agri-food exports: the US (22%), Indonesia (21%), Canada (12%), Russia (11%), Japan (8%), New Zealand (6%), Liberia (5%), Guinea (4%), Gambia (4%), and Philippines (2%) (UNCTAD, 2017). If we compare findings from the literature and data on NTMs, it seems that the phenomenon, from the perspective of reporters, has only been partially explored in the literature. To the best of our knowledge, studies that consider a fuller set of major countries implementing NTMs (e.g. Indonesia, Russia) are scant if existent.

Heterogeneity may be also due to the variety of methodological and empirical approaches: differences emerge in proxies used to measure NTMs and in estimators. For instance, the trade effects tend to be negative if NTMs are proxied by a frequency index and/or coverage ratio (e.g. Jongwanich, 2009) and positive if they are proxied by dummy or count variables (e.g. Shepherd and Wilson, 2013). Considering estimators, negative results are more likely to occur with fixed effects (e.g. Otsuki et al., 2001b; Wilson et al., 2003), while the probability of mixed evidence is higher with a two-stage Helpman-Melitz-Rubinstein model (e.g. Kareem, 2016b).

We find that the magnitude and direction of the estimated effects of NTMs tend to be product- and measure-specific. The trade effects of NTMs tend to be negative for seafood products (e.g. Anders and Caswell, 2009; Kareem, 2016c), meat (Wilson et al., 2003), fruit and vegetables, and cereals and oilseeds (e.g. Otsuki et al., 2001a, b; Scheepers et al., 2007; Drogué and De Maria, 2012; Kareem, 2016a). Vice-versa, trade of traditional commodities, such as coffee, is favoured by NTMs (e.g. Kareem, 2016b), while trade of oils and fats is not affected by beyond-the-border policies (Otsuki et al., 2001a; Xiong and Beghin, 2011). The level of interventions on non-traditional commodities is notably higher than that on traditional commodities: the distribution of NTMs by product category is 26% for fish, 15% for fruit and vegetables, and 11% for meat, but only 3% for traditional commodities (UNCTAD, 2017).

As for specific NTMs, 9 papers deal with MRLs (28% of ETEMs) and 7 studies concern SPSs (45% of ETEMs). In 5 out of 19 cases (27% of ETEMs), empirical literature provides evidence for non-tariff instruments other than MRLs and SPSs, such as TRQs, HACCP, voluntary standards, entry price. Figure 9 shows the empirical distributions (boxplots) and the kernel densities of the ETEMs by types of measure. The variability of ETEMs is lower for papers that analyse SPSs (σ_{SPS} = 2.12) than for papers focused on MRLs (σ_{MRL} = 3.23): while MRLs are highly dispersed towards positive values (with Me_{MRL} = 0.74), SPSs tend to be dispersed towards negative values (with Me_{SPS} = -0.24). Some studies on MRLs provide mixed evidence: for instance, Xiong and Beghin (2011) suggest that the trade potential of African groundnut exporters is more constrained by domestic capacity (e.g. farming and storage practice, other barriers before the border) than by limited market access due to food standards. More frequently, the literature concludes that MRLs tend to act as barrier to trade (e.g. Otsuki et al., 2001 a, b; Wilson et al., 2003; Wilson and Otsuki, 2004; Gebrehiwet et al., 2007; Scheepers et al., 2007). The prevalence of positive ETEMs (48 positive vs. 16 negative) suggests that the higher the levels of MRLs[12], the lower the stringency

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[12] MRLs are frequently proxied by the concentration of a particular substance (e.g. Aflatoxin, Prochloraz, pesticide Chlorpyrifos), generally expressed in parts per million (ppm) or in Mg/Kg, in a certain product.

of the standard. Tighter standards for MRLs determine a trade-impeding effect (e.g. Otsuki et al., 2001a, b; Wilson and Otsuki, 2004; Scheepers et al., 2007).

SPSs may either hamper or facilitate trade. Some studies support the 'standards as barrier' view (Disdier et al., 2008; Jongwanich, 2009), while others provide mixed results (e.g. Kareem, 2016a, b). A plausible explanation of this heterogeneity in findings is the effect of specific regulations: Schlueter et al., (2009: 1489) suggest that some types of SPSs have positive impacts and others have negative influences. The direction of the effect may also depend on the product categories under investigation. Jongwanich (2009) finds that SPSs imposed by developed countries impede processed food exports from developing countries, while Kareem (2016a, b) suggests that the impacts of SPSs on African exports are commodity-specific—trade-enhancing for coffee, but trade-impeding for vegetables, fish, and cocoa, with the trade-impeding effect prevailing. As for other types of non-tariff instruments, some regulatory standards, such as HACCP or entry price, may inhibit the exports of developing countries (Anders and Caswell, 2009; Kareem et al., 2015). In contrast, Wilson and Otsuki (2004) suggest that TRQs are trade-enhancing. Shepherd and Wilson (2013) find that harmonised standards are trade-promoting, while non-harmonised standards are trade-inhibiting, with great differences within specific product categories. As for the category 'Other,' there is a large heterogeneity in estimates (with σ_{Other} = 7.09), with a general tendency toward being trade-impeding (44 negative and 16 positive ETEMs) (fig. 9).

All in all, the empirical literature suggests that NTMs have a deterrent effect on African agri-food trade: this is true in particular for MRLs, SPSs, and other regulatory standards (e.g. HACCP, entry price). The few exceptions to this pattern are tariff rate quotas and harmonised standards. However, differences exist across product categories, and generalisations are difficult to make. A majority of the papers in the literature focus on SPSs intended to protect human health, with little attention devoted to other measures. Export-related measures (0.11 million NTMs), price control measures (0.08 million NTMs), TBTs (0.08 million NTMs), and pre-shipment inspections (0.05 million NTMs) account for 48% of the total NTMs set on African agri-food exports (UNCTAD, 2017).

Figure 9. ETEMs arranged by types of measures.
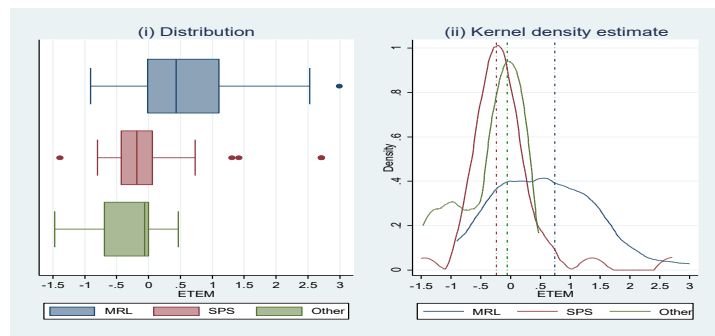
Notes: Other includes tariff rate quotas, HACCP, voluntary standards, entry price. In panel (i) we include observations within the 5th and 95th percentiles. Horizontal lines are median values (Me) (i.e., Me_{MRL}=0.43, Me_{SPS}= -0.19, Me_{Other}= -0.06). In panel (ii) the densities are on full sample. Dashed lines are median values (Me) on full sample (i.e., $Me_{Tot.}$= -0.04, Me_{MRL}=0.74, Me_{SPS}= -0.24, Me_{Other}= -0.06).

4. Further evidence on trade effects of non-tariff measures

Agri-food exports by developing countries have grown exponentially (Martin, 2018) and have been affected by standards contained in bilateral agreements (Disdier et al., 2015). Previous studies highlight that the trade effects of SPSs are geographic-specific: SPSs tend to limit trade both among developed (Yue and Beghin, 2009; Arita et al., 2017) and developing countries (Melo et al., 2014). As for trade from developing to developed countries, SPSs are market-entry barriers for developing countries but facilitate trade once the standards of developed countries are met (Chevassus-Lozza et al., 2008). This heterogeneity may be due to the peculiarity of the SPSs, whose trade effects could be positive or negative (Schlueter et al., 2009: 1489), as well as specific to sectors and to products (Dal Bianco et al., 2016).

We disentangle the trade effects of SPSs by focusing on the most commonly implemented types of SPSs on agri-food trade and on the most commonly regulated product categories, taking into account both developed and developing countries. In particular, we focus on how SPSs may have contributed to change trade patterns (North-North, North-South, South-North, South-South) and assess which types of SPSs were most influential and which products have been most affected. Moreover, we investigate the role of SPSs on the extensive and intensive margins of trade.

4.1. Research design

We follow a standard gravity approach: bilateral trade flows are likely to be directly related to economic masses and inversely related to the economic distance among countries (Anderson and van Wincoop, 2003). The economic masses of reporters (i) and partners (j)[13] and economic distance are taken into account by fixed effects. Following Baldwin and Taglioni (2006), we use time-varying reporter (β_{it}) and time-varying partner (β_{jt}) fixed effects that can capture the effects of multilateral resistance terms and correcting cross-sectional and time-series biases. As suggested by Cheng and Wall (1999) and Mayer et al. (2018), we use country-pair (β_{ij}) fixed effects to account for potential unobserved factors of bilateral proximity, other than the phenomenon of interest.

We model SPSs as count variables. The SPSs are time- (t) and product-specific (k) and related to the implementing (i) and affected (j) countries.[14] The effects of bilateral SPSs on agri-food trade are quantified using the following specification, estimated by the mean of the PPML method:

$$\ln(X_{ij,t}) = \alpha + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T}(\beta_{it} + \beta_{jt} + \beta_{ij}) + \gamma_0 SPS_{ij,t} + \gamma_1^{TR} SPS_{ij,t}^{TR} + \varepsilon_{ij,t} \tag{9}$$

The logarithm of (annual) trade between i and j ($\ln(X_{ij,t})$) is a function of the total number of SPSs ($SPS_{ij,t}$) and of the number of trade route-specific SPSs ($SPS_{ij,t}^{TR}$)[15], α is a constant, γ_0 and γ_1^{TR} are the parameters of interest, and $\varepsilon_{ij,t}$ is the error term (independently and identically distributed, i.i.d.). The superscript *TR* indexes trade routes: specific dummy variables account for countries implementing SPSs (North implementing and South implementing).

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[13] Reporters are origin countries/countries implementing SPSs; partners are destination countries/countries affected by SPSs.
[14] The subscript k has been omitted for clarity.
[15] The term is omitted in global analyses (see section 4.2).

The PPML estimator is widely adopted in gravity-based analyses of trade policies in the agri-food sector (e.g. Hoeckman and Nicita, 2011; Winchester et al., 2012; Beckman and Arita, 2016; Dal Bianco et al., 2016; Arita et al., 2017). It allows us to deal with relevant econometric issues peculiar to gravity-based models: the presence of zero trade flows[16] and heteroskedasticity in the error term (Silva and Tenreyro, 2006). By assuming an additive error, the PPML allows us to account for heteroskedasticity and to avoid selection bias (due to exclusion of zero observations): the marginal effects tend to be more robust in terms of magnitude and statistical and economic significance (Haq et al., 2013).

We compute the marginal effects (ME) of SPSs on trade values as follows:

$$ME(\%) = (e^{\gamma} - 1) * 100 \tag{10}$$

In order to assess how SPSs may affect the intensive and extensive margins of trade ($X_{ij,t}$), we use two different dummy variables as dependent variables. The first dummy variable ($Y_{ij,t}^{IN}$) relates to the intensive margins of trade. It equals 1 if bilateral trade is greater at time t than at time t-1:

$$Y_{ij,t}^{IN} = \begin{cases} 1 \text{ if } X_{ij,t} > X_{ij,t-1} \\ 0 \text{ otherwise} \end{cases} \tag{11}$$

In a similar fashion, the second dummy variable ($Y_{ij,t}^{EX}$) accounts for the extensive margins of trade: it equals 1 if bilateral trade does not exist at time t-1 and is non-zero at time t.

In all cases, we estimate the Probit model (Maddala, 2002: 322). The marginal effects are computed as predicted changes in the probability that $Y_{ij,t}^{n} = 1$. The marginal effects for $SPS_{ij,t}$ are as follows (those for $SPS_{ij,t}^{TR}$ are computed in a similar way):

$$
\begin{aligned}
ME^{SPS_{ij,t}}(\%) &= \Delta\Pr\left(\widehat{Y_{ij,t} = 1}\right) \\
&= \phi\left(\hat{\alpha} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T}(\widehat{\beta_{it}} + \widehat{\beta_{jt}} + \widehat{\beta_{ij}}) + \widehat{\gamma_0} * 1 + \widehat{\gamma_1^{TR}}\overline{SPS_{ij,t}^{TR}}\right) \\
&\quad - \phi\left(\hat{\alpha} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T}(\widehat{\beta_{it}} + \widehat{\beta_{jt}} + \widehat{\beta_{ij}}) + \widehat{\gamma_0} * 0 + \widehat{\gamma_1^{TR}}\overline{SPS_{ij,t}^{TR}}\right)
\end{aligned} \tag{12}
$$

We also use dummy variables to account for product categories and types of SPSs.

In order to investigate route-specific effects of SPSs, we collected bilateral trade flows for 19 countries and data on NTMs for the period 1990-2017. The data sources are the UNCTAD's Global Database and the UN Comtrade database. In particular, the UNCTAD is the most reliable and comprehensive source of data on SPSs, which proxy enforceable requirements. The UNCTAD's database provides information on the date of entry into force and the expiry date of each measure. This allows us to build a proxy for SPS measures that is country-pair and product-specific, covering the entire timeframe on which the measure works.

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[16] Our dataset contains only 0.01% of zero trade flows; thus, the estimates might be slightly biased downwards. Martin and Pham (2008) suggest that, compared to other estimators, PPML tends to underestimate (overestimate) coefficients with few (numerous) zero trade flows.

We refer to the country classification in United Nations (2017) to select Northern (developed) economies (Australia, Canada, the EU, New Zealand, and the US) and Southern (developing) economies (the BRIIC countries, South Africa, Argentina, Bolivia, Peru, Congo, Egypt, Libya, Morocco, and Tunisia). The selected countries account for 77% of global GDP: in 2015, developed economies, the BRIIC countries, Egypt, and Peru are listed as top 25% economies for level of GDP. All these economies have benefited from a general growth in global welfare from 1995 to 2015: in particular, Bolivia and Congo have more than quadrupled their GDPs, while Libya, Morocco, and Tunisia have tripled their GDPs (CEPII, 2017). Since 2000, the importance of developing economies and of the BRIIC countries in particular has driven the development of global agri-food markets. In particular, most of the increased share of the BRIIC countries' agri-food trade represents increased trade with other BRIIC countries (Greenville, 2015).

We focus on 8 categories of agri-food products that are among the most regulated in the sector, coded according to HS 2-Digit Chapter Headings: meat (02), fish (03), dairy products (04), vegetables (07), fruit (08), oilseeds (12), cereals (10), and preparations of meat and fish (16).

We investigate the global effect of SPSs and disentangle it for 7 types of SPSs (the most implemented ones), coded according to the UNCTAD (2012) classification: geographic restrictions on eligibility (A120), special authorisation requirement for SPS reasons (A140), tolerance limits for residues of or contamination by certain (non-microbiological) substances (A210), labelling requirements (A310) packaging requirements (A330), testing requirement (A820), and certification requirement (A830).

Table 6 lists and describes dependent and independent variables.

Table 6. Description of variables and basic statistics.

Variable	Description	Type	Detail	Mean	Std. Dev.
X	Trade flows in billion US$	Numerical	0 (min), 20.30 (max)	0.10	0.55
Y^{IN}	Intensive margins of trade	Dummy	1 if trade increases (0 otherwise)	0.24	0.42
Y^{CR}	Trade creation	Dummy	1 if trade is created (0 otherwise)	0.58	0.49
Y^{DV}	Trade diversion	Dummy	1 if trade is diverted (0 otherwise)	0.14	0.34
SPS	Number of SPSs	Count	1 (min), 84 (max)	1.63	2.73
SPS^{NN-NS}	Number of SPSs implemented by developed countries (North-North, North-South)	Count	0 (min), 84 (max)	1.18	2.86
SPS^{SS-SN}	Number of SPSs implemented by developing countries (South-South, South-North)	Count	0 (min), 7 (max)	0.46	0.59
D^{02}	Meat	Dummy	1 if product is meat (0 otherwise)	0.24	0.42
D^{03}	Fish	Dummy	1 if product is fish (0 otherwise)	0.21	0.41
D^{04}	Dairy products	Dummy	1 if product is dairy product (0 otherwise)	0.13	0.34
D^{07}	Vegetables	Dummy	1 if product is vegetables (0 otherwise)	0.11	0.31
D^{08}	Fruit	Dummy	1 if product is fruit (0 otherwise)	0.11	0.32
D^{10}	Cereals	Dummy	1 if product is cereals (0 otherwise)	0.04	0.20
D^{12}	Oilseeds	Dummy	1 if product is oilseeds (0 otherwise)	0.06	0.25
D^{16}	Preparation of meat and fish	Dummy	1 if product is preparation of meat and fish (0 otherwise)	0.10	0.29
D^{A120}	Geographic restrictions on eligibility	Dummy	1 if SPS is A120 (0 otherwise)	0.09	0.29
D^{A140}	Special authorisation requirement for SPS reasons	Dummy	1 if SPS is A140 (0 otherwise)	0.14	0.35
D^{A210}	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	Dummy	1 if SPS is A210 (0 otherwise)	0.08	0.26
D^{A310}	Labelling requirements	Dummy	1 if SPS is A310 (0 otherwise)	0.04	0.20
D^{A330}	Packaging requirements	Dummy	1 if SPS is A330 (0 otherwise)	0.05	0.21
D^{A820}	Testing requirement	Dummy	1 if SPS is A820 (0 otherwise)	0.06	0.23
D^{A830}	Certification requirement	Dummy	1 if SPS is A830 (0 otherwise)	0.16	0.37

4.2. Results and discussion

We estimate a gravity-type model using a PPML estimator and compute the marginal effects of SPSs on trade. We assess (i) the global effects and (ii) the effects on trade from developed countries (North-North [N-N] and North-South [N-S]) (table 7).

Table 7. Results of PPML and marginal effects of SPSs: general trend (i); trade pattern differences (ii).

Variables	(i)		(ii)	
	PPML	Marginal effect	PPML	Marginal effect
Time-varying importer f.e.	Yes		Yes	
Time-varying exporter f.e.	Yes		Yes	
Country-pair fixed effect	Yes		Yes	
SPS_t	-0.0005 *** (0.0001)	-0.05%	0.0085 *** (0.0007)	0.85%
SPS_t^{NN-NS}			-0.0090 *** (0.0007)	-0.90%
Constant	2.1710 *** (0.0213)		2.1630 *** (0.0213)	
Observations	800,668		800,668	
R-squared	0.462		0.463	

Notes: Robust standard errors are in parentheses. *** indicates statistical significance at 1%. f.e. = fixed effects.

At a global level, we find that SPSs tend to limit trade: we assess a marginal reduction of trade of 0.05%. This result supports the findings of Peterson et al. (2013), who show that phytosanitary measures implemented by the US have negative trade effects. Our results, however, go further, indicating that the effects of SPSs implemented by Northern countries differ depending on whether the exporter is from the North or the South (ii): positive for 'SPS_t' and negative for 'SPS_t^{NN-NS}', suggesting that the SPSs implemented by developed countries are more trade-impeding.

The Probit models show how SPSs affect the probability of intensive and extensive margins of trade . The estimated coefficients for 'SPS_t' are positive for the intensive margins and negative for the extensive margins of trade, at global level and for route-specific trade: SPSs favour the increase of existing trade and impede the realisation of new trade patterns. A plausible explanation is that SPSs function as market entry barriers by imposing sunk costs (Crivelli and Gröschl, 2016), even though SPSs may enhance flows in existing patterns of trade; put differently, for existing trade patterns, SPSs reduce market imperfections and the costs of entering the market and thus increase trade volumes (Xiong and Beghin, 2014).

The trade effects are lower for SPSs implemented by developed countries: the coefficients for 'SPS_{t-1}^{NN-NS}' are negative for the intensive margins and positive for the extensive margins of trade. By deduction, the coefficients estimated for the variable 'SPS_t', in the specification for trade patterns, proxy the effects of SPSs on trade originating from the South. Our findings highlight that SPSs implemented by developed countries tend to boost the probability of new trade patterns to the detriment of existing trade; the opposite is true for developing countries. SPSs are less challenging for developed than for developing countries, as the latter frequently lack the financial and technical capacity needed to comply with more stringent standards (Athukorala and Jayasuriya, 2003; Jongwanich, 2009). In this regard, it may be easier for developing countries to strengthen existing trade relations and for developed countries to enter new markets.

In order to investigate how the trade effects of SPSs vary across commodities and across types of intervention, we perform product- and SPS-specific analyses. PPML and Probit models are estimated for meat, fish, dairy products, vegetables, fruit, cereals, oilseeds, and preparations of meat and fish.[17] Moreover, we run models to take into account the specific effects of geographical restrictions on eligibility (A120), special authorisation requirement for SPS reasons (A140), tolerance limits for residues of or contamination by certain (non-microbiological) substances (A210), labelling and packaging requirements (A310 and A330), and testing and certification requirements (A820 and A830).[18] In all cases, we disentangle the global effects (i) from those related to SPSs implemented by developed countries (i.e. North-North and North-South trade) (ii).

General results are supported and strengthened by product-specific and SPS-specific analyses. We found that SPSs enhance trade: this is true also for SPS implemented by Northern countries. In addition, SPSs increase trade but limit its creation and diversion: these effects are confirmed also in our sensitivity analysis. In particular, results of the PPML model show that the coefficients estimated for 'SPS_t^{NN-NS}' are positive in product-specific analyses and negative in SPS-specific analyses, suggesting that the effects of SPSs tend to be product-specific: in fact, SPSs are correlated with the type of product; thus, their effects are likely to differ across sectors. Similarly, Dal Bianco et al. (2016: 33) argue that "the effects of non-tariff measures on trade are likely to be sector- and country-specific depending on several aspects."

We find that SPSs are trade-impeding for all product categories. In particular, SPSs have the greatest impact on trade of preparations of meat and fish, which decrease by 3.7% at global level and by 2.8% if SPSs are implemented by a Northern country; the lowest effects are for SPSs implemented by Northern countries on oilseeds (-0.5%) and fruit (-0.8%).[19] Similarly, Melo et al. (2014) and Jayasinghe et al. (2010) found that SPSs negatively affect trade in fruit and oilseeds. Our findings are also in line with Winchester et al. (2012), who found a trade-restrictive role of SPSs for meat, dairy products, fruit and vegetables, and oilseeds.

SPSs tend to favour the intensive margins, but not the extensive margins of trade. The greatest effects are on fish and cereals. Few differences emerge for SPSs implemented by Northern countries: the intensive margins are favoured, and the extensive margins are impeded (exception made for fish) (table 8).

As for SPS-specific analysis, trade is facilitated, regardless of the type of measure (i), but the same tendency is not true for SPSs implemented by Northern countries (ii). Prohibitions or restrictions to import a final product (A120 and A140) and packaging (A330) and certification (A830) requirements tend to be trade-enhancing. These results are in line with those of Schlueter et al. (2009), who suggest that prevention measures are trade-promoting for North-North trade. In contrast, labelling (A310) and testing (A820) requirements are trade-impeding. In fact, redundant testing of products requires additional time to comply with administrative requirements and inspection procedures, with potentially negative impacts on the profitability of specific markets (Crivelli and Gröschl, 2016).

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[17] We drop the variables 'Cereals' from the PPML model and 'Preparation of meat and fish' from the Probit models due to a strong collinearity with other product categories.
[18] The regressor A210 was omitted in the PPML and Probit models since SPS A210 is never implemented by Northern countries during the period studied.
[19] Tables of results of the PPML specific for product categories are omitted for brevity, but available upon request.

Labelling and packaging requirements (A310 and A330, respectively), which are both related to product characteristics, have the greatest impact on the intensive margins of trade (+10% on average) (table 9, column A, i). The extensive margins of trade are more likely to occur for geographic restrictions on eligibility (A120), special authorisation requirements for SPSs (A140), and certification requirements (A830), while testing (A820), labelling (A310), and packaging (A330) requirements reduce the probability of intensive margins (table 9, column B, i).

As for SPSs implemented by Northern countries (ii), geographic restrictions on eligibility (A120) and special authorisation requirements for SPSs (A140) favour both intensive and extensive margins of trade. We find mixed evidence for labelling (A310), packaging (A330), testing (A820), and certification (A830) requirements: labelling and testing requirements tend to impede the intensive margins but favour the extensive margins of trade. The opposite occurs for packaging requirements. Certification requirements, in contrast, increase by the probability of extensive margins by 0.4% (table 9, column B, ii). In fact, it is more likely that SPSs related to product characteristics, such as packaging, increase trade due to a reduction of asymmetric information for consumers (Crivelli and Gröschl, 2016). By limiting trade diversion, "conformity assessment-related measures [A830] constitute market entry barriers, probably due to the relatively high costs and burdensome procedures they impose on foreign producers" (Crivelli and Gröschl, 2016: 462).

Overall, we find that the trade effects of SPSs differ by trade patterns and by type of measure: different types of SPSs entail different costs of compliance (Crivelli and Gröschl, 2016); each instrument pursues a specific political objective (Schlueter et al., 2009).

Table 8. Marginal effects of SPSs on intensive (A) and extensive (B) margins of trade by product category: general trend (i);trade pattern differences (ii).

Product category	Intensive margins (A)		Extensive margins (B)	
	(i)	(ii)	(i)	(ii)
Meat (02)	+4.2%	+5.2%	-11.%	-13.2%
Fish (03)	+17.3%	-0.9%	-24.0%	+4.2%
Dairy products (04)	+7.0%	+7.6%	-8.9%	-9.4%
Vegetables (07)	+4.3%	+4.7%	-5.0%	-5.7%
Fruit (08)	+3.7%	+3.9%	-4.4%	-4.5%
Cereals (10)	+8.1%	+6.2%	-21.5%	-20.8%
Oilseeds (12)	+3.2%	+3.7%	-2.9%	-3.8%

Table 9. Marginal effects of SPSs on intensive (A) and extensive (B) margins of trade by types of SPS: general trend (i) and trade pattern differences (ii).

Types of SPSs	Intensive margins (A)		Extensive margins (B)	
	(i)	(ii)	(i)	(ii)
Geographic restrictions on eligibility (A120)	+1.1%	+1.3%	+1.4%	+1.2%
Special authorisation requirement for SPS reasons (A140)	+0.7%	+0.8%	+2.0%	+1.8%
Tolerance limits for residues of certain substances (A210)	n.a.	n.a.	n.a.	n.a.
Labelling requirements (A310)	+8.4%	-4.0%	-11.4%	+6.0%
Packaging requirements (A330)	+11.6%	+13.4%	-16.8%	-19.6%
Testing requirement (A820)	+4.6%	-12.1%	-6.9%	+19.2%
Certification requirement (A830)	n.a.	n.a.	+0.6%	+0.4%

Note: n.a.=not available.

4.3   A case study: the effects of NTMs on world wine trade

The substantial reduction of tariffs and consequent exponential increase of NTMs that occurred in the agri-food sector during the mid-1990s have particularly affected wine trade. In fact, high levels of tariffs and bilateral NTMs coexist in the wine sector: many observers have concluded that wine trade is overregulated and that the level of overall intervention has been steady for years (e.g. Foster and Spencer, 2002; Anderson and Golin, 2004). Plausibly, governments tend to seek additional revenues through tariffs, standards, and bilateral NTMs (Schnabel and Storchmann, 2010; Storchmann, 2012).

Although there is a large literature on the influence of NTMs on agri-food trade, only a few studies have investigated their influence on the wine trade. Olper and Raimondi (2008) estimate the effect of NTMs on trade of processed food (e.g. spirits, wine, malt, drinks, oils and fats, milling products, and bakery), concluding that NTMs play a trade-reducing role. On global trade of bottled wine, Dal Bianco et al. (2016) find that SPSs do not seem to obstruct exports, while TBTs have heterogeneous impacts on trade. Meloni and Swinnen (2017a, b) investigate the impact of standards on wine trade between France and Greece and conclude that standards reduced Greek exports.

Using a gravity model, we investigate how and to what extent bilateral NTMs influence wine imports. In particular, we disentangle the contribution of bilateral NTMs mostly implemented on wine imports (SPSs, TBTs, pre-shipment inspections, and export-related measures). We also examine the effects of NTMs for four market segments of wine: sparkling, still bottled, still bulk, and musts. This level of detail allows us to identify which regulation is the most influential and which segments tend to react more to bilateral trade regulations.

To facilitate our empirical analysis, we focus on 24 countries that include the main exporters, importers, and producers of wine during the period 1991-2016. In the four market segments identified above, the wine imports of these 24 countries cover more than 90% of global wine trade (in terms of value) and production (in terms of volume) (Anderson and Pinnilla, 2017). The countries include developed (North, 62%) and developing (South, 38%) countries, as well as Old World Producers (OWP, 46%) and New World Producers (NWP, 54%)[20] (Anderson and Nelgen, 2015). Comparing average values of imports and exports during 1991-2016, 62% of countries may be classified as net importers (NI) and 38% as net exporters (NE) (UN Comtrade, 2018).

Imports showed notable growth in the period 1991-2008 due to increased consumption in non-producing countries and a recovery in 2011 after a reduction in 2009 due to the international economic crisis. Increased consumption in non-producing countries (i.e. New World consumers, such as Asian countries) offset the gradual reduction of consumption in OWP countries (Anderson, 2013; Anderson and Wittwer, 2015). Emblematic is the case of China, where consumption increased from 5 to 16 million hl between 2006 and 2016. In addition, OWP production

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[20] Belgium-Luxembourg, Denmark, France, Germany, Ireland, Italy, Portugal, Spain, Sweden, Switzerland, United Kingdom are OWP; Argentina, Australia, Brazil, Canada, Chile, China, Hong Kong, Japan, New Zealand, Russia, Singapore, South Africa, United States are NWP.

volumes have been steady, whereas NWP have exponentially increased their production and exports (from US$78 million to US$7,885 million between 1986 and 2016) (Anderson and Pinilla, 2017).

Comparing the evolution of average values of imports across decades (table 10), we find the highest increase from 2000-01 to 2010-11 for all wines (+95%). Differences emerge across market segments: since 1990, imports of some types of wine have grown more than others. Sparkling and bottled wines increased the most (Pomarici, 2016; del Rey, 2018): bottled wines doubled from 1990-91 to 2000-01, and again from 2000-01 to 2010-11, while in 2015-16, bottled wine imports grew by 9%. Bulk wine has tripled from 2000-01 to 2010-11 (Mariani et al., 2012), while musts have shown a progressive downward trend after an increase from 1990-91 to 2000-01 (+23%).

Table 10. Wine imports by market segment

Market segment	Unit of measure	1990-91	2000-01	2010-11	2015-16
Sparkling	Million US$	6	6	11	16
Bottled	Million US$	10	20	40	44
Bulk	Million US$	4	3	10	9
Musts	Million US$	1	1	1	1
All wines	Million US$	7	11	21	23

Source : elaboration on UN Comtrade (2018).

During 2015-16, the US, the United Kingdom (UK), Germany, China, and Canada were the top 5 importers of all wines and of bottled wine. Germany, the UK, and the US have long been major destinations for wine exports; Canada is the first importer among traditional importing countries, whereas China is the first importer among non-traditional importing countries (Mariani et al., 2012). Relevant importers of sparkling wine are Japan and Singapore (that overstep China and Canada). Germany, the UK, and the US are the leading importers of bulk wine, followed by France and Sweden. Musts (not imported by Russia, New Zealand, and Argentina) cover a relevant share of wine imports for Japan and several European countries (Portugal, Germany, Italy, and France).

Global trade patterns changed considerably changed between 1996 and 2016: trade between OWP has drastically reduced (from 65% to 27%, in 1996-2016) in favour of a relevant increase in imports of NWP (from 22% to 44% from OWP, and from 4% to 21% from NWP, in 1996-2016). In 2016, NWP absorbed 65% of global imports, and Northern countries were the buyers of 77% (UN Comtrade, 2018). Changes in the relevance of countries' groups in global wine market are significant: NWP have gained increasing market shares, driven by Northern countries (e.g. the US, Canada, Australia, and New Zealand).

The level of bilateral NTMs, almost stable until 2010 (Phase I), approximately doubled in 2011 (from 152 to 299 in 2010-2011) (Phase II) and again in 2015 (reaching 561 that year) (Phase III). The three phases describe structural changes in the trend of bilateral NTMs, due to the introduction of different types of measures. The most and the least adopted NTMs are TBTs (75%) and SPSs (1%), respectively; others are pre-shipment inspections and export-related measures (24% in total).

Bilateral NTMs are segment-specific. TBTs are the most widespread across product categories. For sparkling and still wines, TBTs were approximately constant until 2010 and have sharply increased since 2011: the relevant increase in TBTs may explain the raise in total level of NTMs and the transition from 'Phase I' and 'Phase II.' For musts, TBTs fluctuated from 10 to 30 during 1991-2016. SPSs and pre-shipment inspections have been implemented only since 2011 for all segments. Relevant is the increase in the number of pre-shipment inspections and export-related measures since 2015 for wines (sparkling, bottled, and bulk): in particular, export-related measures have been implemented by 5 out of 13 NWP (Australia, Canada, Russia, Singapore, and the US), while pre-shipment inspections have been adopted in 3 out of 13 NWP (Canada, Russia, and the US) (UNCTAD, 2017). Their wide increase in 2015 may have determined the transition from 'Phase II' and 'Phase III'.

Table 10 lists and describes specific types of NTMs implemented for wine imports. Types of bilateral NTMs on wine imports differ across trade partners. Bilateral NTMs implemented by NWP more than tripled between 1996 and 2016 (from 76 to 240 in NWP-OWP trade, from 81 to 300 in NWP-NWP trade) (UNCTAD, 2017). In general, OWP tend to adopt import tariffs rather than bilateral NTMs (Rickard et al., 2014, 2017; Global Trade Alert, 2018). Governments have substantially increased the use of technical measures in order to protect domestic markets (Anderson and Golin, 2004): by 2016, North had implemented 126 TBTs against other developed countries (59%) and 87 TBTs to regulate imports from South (41%) (UNCTAD, 2017). There was almost no recourse to SPSs (as of 2016, 6 SPSs had been implemented worldwide): in general, they concern trade of fresh products (Dal Bianco et al., 2016). Not negligible in 2016 were the shares of pre-shipment inspections (23%) and export-related measures (36%): NWP have implemented them against OWP (about 43%) and other NWP (approximately 57%) (UNCTAD, 2017). Net importers adopt TBTs and pre-shipment inspections, while net exporters use SPSs only against other net exporters. Export-related measures are implemented by both net importers and net exporters.

Table 11. Classification and description of NTMs implemented in wine sector

Chapter	Classification	Description
A	Sanitary and Phytosanitary Standards (SPSs)	Measures that are applied to protect human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms in their food; to protect human life from plant- or animal-carried diseases; to protect animal or plant life from pests, diseases, or disease-causing organisms; to prevent or limit other damage to a country from the entry, establishment or spread of pests; and to protect biodiversity.
A220	Restricted use of certain substances in food and feed and their contact materials	Restriction or prohibition on the use of certain substances contained in food and feed. It includes the restrictions on substances contained in the food containers that might migrate to food.
B	Technical Barriers to Trade (TBTs)	Measures referring to technical regulations, and procedures for assessment of conformity with technical regulations and standards, excluding measures covered by the SPS Agreement.
B330	Packaging requirements	Measures regulating the mode in which goods must be or cannot be packed, and defining the packaging materials to be used.
B420	TBT regulations on transport and storage	Requirements on certain conditions under which products should be stored and/or transported.
B830	Certification requirement	Certification of conformity with a given regulation: required by the importing country but may be issued in the exporting or the importing country.
C	Pre-Shipment inspections	Compulsory quality, quantity and price control of goods prior to shipment from the exporting country, conducted by an independent inspecting agency mandated by the authorities of the importing country.
C200	Direct consignment requirement	Requirement that goods must be shipped directly from the country of origin, without stopping at a third country.
C900	Other formalities, n.e.s.	Other formalities not elsewhere specified.
P	Export-related measures	Export-related measures are measures applied by the government of the exporting country on exported goods.
P130	Licensing- or permit requirements to export	A requirement to obtain a licence or a permit by the government of the exporting country to export products.
P500	Export taxes and charges	Taxes collected on exported goods by the government of the exporting country: they can be set either on a specific or an ad valorem basis.
P620	Certifications required by the exporting country	Requirement by the exporting country to obtain sanitary, phytosanitary or other certification before the goods are exported.
P690	Export measures, n.e.s.	Export measures not elsewhere specified.

Source: UNCTAD (2012).

The level of intervention is emblematic in trade between countries with similar levels of economic development. In North-North trade, NTMs more than doubled in 2016, after a period of relative stability from 1996 to 2006; in South-South trade, absent until 2006, bilateral NTMs numbered 48 in 2016. In trade between countries with different levels of economic development, the number of policy measures changes drastically depending on if they are imposed by the North or by the South: NTMs implemented by South against North are rather scant (87 measures in 2016), compared to NTMs adopted by North against South (169 in 2016) (UNCTAD, 2017). The frequent adoption of NTMs by developed countries may lead to a non-transparent trade policy environment (Athukorala and Jayasuriya, 2003), which may be detrimental in particular for trade from developing countries of NWP (e.g. Argentina, Chile, Uruguay, South Africa), which have yet to find alternative outlet to their production.

In order to investigate the impact of bilateral NTMs on global wine trade, we use a standard gravity approach: bilateral trade flows are likely to be explained by economic masses, and by the economic distance between countries (Anderson and van Wincoop, 2003). Following Baldwin and Taglioni (2006), we proxy economic masses of importing (*i*) and exporting (*j*) countries with importer (β_i) and exporter (β_j) fixed effects, so as to account for multilateral trade resistance. The fixed effects capture size effect and control for country-specific unobserved heterogeneity (Cardamone, 2011). We use time fixed effects (β_t) to control for time-specific events.

We model NTMs as dummy variables, equal to 1 if the NTM is in place (0 otherwise). The NTMs are time-specific (*t*) and related to the implementing country (*i*), the partner country (*j*), and the wine category (k)[21]:

$$\ln\left(X_{ij,k}\right) = \alpha + \sum_{i=1}^{I} \beta_i + \sum_{j=1}^{J} \beta_j + \sum_{t=1}^{T} \beta_t + \sum_{k=1}^{K} \gamma_k NTM_{ij,k} + \varepsilon \tag{13}$$

where $\ln\left(X_{ij,k}\right)$ is the logarithm of (annual) imports of the *k*-th wine category between *i* and *j*, α is a constant, γ_k is the parameter of interest, and ε is the error term.

We estimate the model using a PPML estimator and compute the trade effects (TE) of an additional NTM on import values in percentage terms by exponentiating the coefficients of PPML estimation procedure:

$$TE_k(\%) = (e^{\gamma_k} - 1) * 100 \tag{14}$$

We distinguish between net importers and net exporters in order to isolate potential differences in the effects of the bilateral NTMs on imports that may be due to the sign of the trade balance.

We use imports of four product categories:

- Wine, sparkling (HS 6-digit code 220410),
- Wine, still, in containers holding 2 l or less (220421),
- Wine, still, in containers holding more than 2 l (220429), and
- Grape must (220430).

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[21] The subscript *t* has been omitted for clarity.

We include all types of bilateral NTMs applied to wine imports: SPSs, TBTs, and pre-shipment inspections. We collected bilateral annual data from the Global Database on Non-Tariff Measures for NTMs and from the UN Comtrade database for imports.

We estimate a PPML model, and compute the TE of bilateral NTMs on imports, in order to disentangle how different types of NTMs affect global trade of wine and of its segments (table 12). Results suggest that the trade effects of bilateral NTMs are segment-specific, and differences emerge across types of NTMs.

We find positive coefficients for SPSs and pre-shipment inspections: as expected, bilateral NTMs tend to facilitate global trade of wine. This is true, in particular, for SPSs: on average, the SPSs are the most influential on imports. Global imports also rise if pre-shipment inspections are implemented, but their impacts are not as large as those observed for SPSs. Our results complement the findings of Dal Bianco et al. (2016), who focus on exports of wine. In particular, we find that SPSs enhance imports, while they determine that they have no impact on exports; we find that technical measures have mixed effects on imports, while they conclude that technical measures are important frictions for exports.

As for the segment-specific analyses, we find that bilateral NTMs enhance trade, exception made for the TBTs, whose effects are segment-specific. Moreover, the SPSs are trade-enhancing: they greatly affect imports of bulk wine. The effects of pre-shipment inspections are mainly due to their positive effect on bottled wine. The TBTs affect bottled and bulk wine, but the evidence is mixed: imports of bottled wine are favoured, while imports of bulk wine are impeded. The differences we observe for bottled and bulk wine may be due to changes in the composition of import flows: during the last several decades, bulk wine has gained market share to the detriment of to bottled wine (Castillo et al., 2016). Large volumes of bulk wine are imported and bottled in the target market: thus, it is plausible that, compared to bulk wine, bottled wine is more likely to meet technical standards (e.g. packaging requirements, regulations on transport and storage, certification requirements) and, as a consequence, is likely to be imported in larger volumes. Our findings mirror those of Dal Bianco et al. (2016) for TBTs: for bottled wine, they suggest that TBTs impede exports, and we show that TBTs favour imports.

We highlight how the trade effects of NTMs differ between net importers and net exporters (table 13). TBTs and pre-shipment inspections are implemented only by net importers. TBTs are trade-enhancing for bottled wine but trade-impeding for bulk wine. The trade-impeding effect of TBTs for bulk wine of net importers may be due to the high specialisation of some competitors, that are net exporters of bulk wine (i.e. Australia, New Zealand, and Spain) (Mariani et al., 2012). Pre-shipment inspections increase imports of bottled wine. SPSs are adopted only by net exporters, and increase imports of wine.

Our results highlight that the regulation of wine imports is quite heterogeneous across countries. Net importers are frequent adopters of TBTs and tend to impose formalities that should precede the shipments from exporting countries. Net exporters prefer SPSs aimed at ensuring food safety and preventing the dissemination of disease or pests.

Table 12. Results of PPML estimation and trade effects on import values.

Variable	All wine		Sparkling		Bottled		Bulk		Musts	
	PPML	TE	PPML	TE	PPML	TE	PPML	TE	PPML	TE
Importer fixed effects	Yes		Yes		Yes		Yes		Yes	
Exporter fixed effects	Yes		Yes		Yes		Yes		Yes	
Time fixed effects	Yes		Yes		Yes		Yes		Yes	
Sanitary and Phytosanitary Standards (SPSs)	0.27 *** (0.02)	31%	0.24 *** (0.02)	27%	0.25 *** (0.01)	28%	0.32 *** (0.02)	38%	No	
Technical Barriers to Trade (TBTs)	0.02 (0.02)		0.03 (0.03)		0.04 ** (0.02)	4%	-0.10 ** (0.04)	-9%	-0.01 (0.10)	
Pre-shipment inspections	0.05 *** (0.02)	5%	0.03 (0.03)		0.05 *** (0.02)	5%	-0.04 (0.04)		0.08 (0.11)	
Constant	1.76 *** (0.02)		2.19 *** (0.03)		1.58 *** (0.03)		2.12 *** (0.08)		2.27 *** (0.08)	
Observations	27,854		8,192		10,971		6,832		1,859	
R-squared	0.46		0.66		0.76		0.60		0.54	

Notes: Robust standard errors are in parentheses. *** and ** indicate statistical significance at 1% and 5%. PPML = Poisson Pseudo Maximum Likelihood. TE = trade effects. 'No' signals the exclusion of regressors due to the lack of observations for specific measures in certain product categories between pairs of countries.

Table 13. Trade effects on import values: detail on net importers and net exporters.

Variable	All wine		Sparkling		Bottled		Bulk		Musts	
	Net importers	Net exporters	Net importers	Net exporters	Net importers	Net exporters	Net importers	Net exporters	Net importers	Net exporters
Sanitary and Phytosanitary Standards (SPSs)	No	42%	No	43%	No	41%	No	48%	No	No
Technical Barriers to Trade (TBTs)	No	No	No	No	4%	No	-10%	No	No	No
Pre-shipment inspections	4%	No	No	No	4%	No	No	No	No	No

Note: 'No' signals no effects on trade.

5. Conclusions and policy implications

Agri-food trade involving the developing countries has experienced remarkable growth since the WTO's creation in 1994 (Martin, 2018). Several determinants caused this change: economic globalisation (Henson and Loader, 2001), changes in the composition of trade (Henson et al., 2000), progressive trade liberalisation (Sun and Reed, 2010), growing trade agreements (Grant and Lambert, 2008), and reorganisation of policy interventions (Arita et al., 2017). In particular, the proliferation of non-tariff measures (NTMs) seems to have played an important role in modifying trade patterns.

NTMs are capable of shaping trade in the same way as traditional tariffs. Zezza et al. (2017: 30-31) note that "international trade agreements such as the WTO have contributed to a global reduction in tariffs, [and] it is often argued that countries have turned to standards as new instruments to shield their domestic markets from foreign competition." Since the WTO's creation, the number of NTMs has tripled and, in particular, Sanitary and Phytosanitary Standards (SPSs) have grown exponentially in terms of product coverage and number of implementing countries. SPSs are suitable to regulate trade of perishable agri-food products, such as meat-based and seafood products, fruit and vegetables, cereals, and fats and oils (Grant and Arita, 2017). In addition, the implementation of SPSs has shifted from being a prerogative of developed countries to an activity in which both developed and developing countries take part (Martin, 2018).

Comparing the evolution of trade and of NTMs in the agri-food sector (Section 2), we conclude that growing trade flows stimulated the increase in trade policy measures and, in their turn, NTMs contributed to the reshaping of agri-food trade. In the words of Zezza et al. (2017: 30), "the rapid spread and growth of standards across the world has coincided with the growth of global trade in agricultural products."

The combination of greater trade openness and increased use of NTMs has stimulated an interesting academic debate. Discriminating between the economics and the politics of NTMs is a challenge for academics and policymakers: NTMs stimulate trade by reducing transaction costs, information asymmetries, and negative externalities, but they also hinder trade by assuming protectionist scopes (Xiong and Beghin, 2014; Swinnen, 2017). Accordingly, two opposite views prevail in the literature: 'standards as barrier' versus 'standards as catalyst,' with the empirical evidence being quite heterogeneous. In order to characterize the heterogeneity in estimates, we qualitatively and quantitatively reviewed the existing literature on the effects of NTMs on global agri-food trade. Building on existing evidence provided in Li and Beghin (2012), we further explained the differences in findings as a function of types of NTMs, proxies used for NTMs, level of details of studies, and publication process.

Our results (Section 3) highlight that the direction and magnitude of the estimated trade effects of NTMs are case-specific. This is in line with Livingston et al. (2008), who suggest that "in evaluating [import bans and other sanitary and phytosanitary measures], economists try to measure the benefits of imports against the management, production, market, and/or resource costs that might be associated with an outbreak of a disease or pest. Studies show that this varies on a case-by-case basis." Thus, the trade effects of NTMs are likely to depend on specific countries, products, and standards: generalisations are not feasible. A plausible explanation is that the variability in trade effects reflects divergences among countries' food safety regulations and standards, differences in consumers' preferences across countries, ability (or limited

capacity) to produce safe food, and willingness to pay for risk-reducing technology (Buzby and Mitchell, 2006; Jongwanich, 2009).

The literature on SPSs and their impact on agri-food trade has produced mixed evidence and left some important issues underinvestigated. In this light, we deepened our examination of this topic by distinguishing among the effects on developed and developing countries and by focusing on the most regulated product categories. Through a gravity model approach and several Probit specifications, we quantified the trade effects of SPSs and their impacts on the intensive and extensive margins of trade. Overall, we found that SPSs tend to impede trade, although the effect strongly depends on the types of trade partners involved (Section 4), with SPSs implemented by developed countries tending to be more trade-impeding. Overall, SPSs favour the intensive margins of trade between existing trade partners but tend to impede the formation of new trading relationships (extensive margins of trade). These effects are lower for SPSs implemented by developed countries.

Differences between developed and developing countries may be due to the fact that food safety risks vary internationally, depending on differences in the available technology, plant and livestock host factors, food production practices, cultural background, and pedo-climatic conditions. As a consequence, divergences in food safety regulations and standards between importers and exporters may lead to disputes that impede international trade (Buzby and Mitchell, 2006). In this regard, adopting international standards allows countries to avoid redundant costs and potential obstacles to trade (FAO, 2017).

Our analysis poses questions on the stringency of SPSs implemented by developed countries. Frequently, concerns of developed countries are related to onerous controls and absence of transparency in procedures adopted by trading partners, developing countries in particular. In fact, SPSs requirements may be particularly challenging for developing countries, due to lack of knowledge about regulations, methods and facilities to monitor hazards, financial capacity and technical ability to meet requirements, inspections, responsibility of local authorities (Muaz, 2005). However, agri-food trade is a relevant opportunity for developing countries to increase their incomes and improve economic development (FAO, 2017). As suggested by Zezza et al. (2017: 20), "overcoming bureaucratic, procedural and structural obstacles through consistent engagement of public and private stakeholders, improved dialogue are the main pathways to international regulatory convergence." For instance, recognise and accept standards and regulations of trading partners, learn from each other's successes in managing food safety emergences, collaborate to adopt common or international standards set by a third party, or reach compromises on conflicting standards are cooperative efforts that countries should undertake, in order to address food safety and trade issues in a perspective of international convergence (Buzby and Mitchell, 2006). Our results also suggest that the effects of SPSs differ by commodity and by type of measure. We show the differences for SPSs set by developed countries.

Several aspects are left and deserve further attention. In particular, the role played by regional trade agreements (RTAs) is of great relevance: RTAs may modify the effects of SPSs on trade, and the heterogeneous effects implied by SPSs suggest that such standards themselves are heterogeneous. Understanding their degree of equivalency is a further step needed to assess the role of SPS in re-shaping agri-food trade.

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