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RESEARCH ARTICLE

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Regulatory patterns in international pork trade and similarity with the EU SPS/TBT standards

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Abstract

Aim of study: With the increasing protagonism of non-tariff measures (NTMs) in trade policy, better indexes are needed to depict the prevalence and similarity of NTMs across countries for further use in trade impact assessments.

Area of study: Worldwide, with special focus on the European Union (EU)

Material and methods: Using the TRAINS database on NTMs, we calculated and proposed some indicators, stressing both regulatory intensity and diversity, as well as similarity of regulatory patterns between trade partners. Our application focuses on pork trade and main importers, amongst which, the EU is singled out.

Main results: We found a high level of heterogeneity in NTMs' application, both, in the number and variety of measures. The bilateral similarity was relatively low, such as only 30% of sanitary and phytosanitary measures (SPS) and 20% of technical barriers to trade were shared, providing ground and incentive for discussing trade policy harmonization. Our analysis suggests that SPS regulations prevail in those sectors and countries more engaged in trade, while a negative correlation with tariffs raises protectionism concerns. Our bilateral indicators rank country pairs according to the similarity of their regulatory patterns. The EU, for instance, is closer in SPS regulations to China or USA than to Canada or New Zealand, which will require actions in the context of the bilateral trade agreements in course.

Research highlights: The low similarity of regulatory patterns evidence the challenges faced by policy makers to streamline technical regulations. For an accurate representation of regulatory patterns and their impact on trade, both uni- and bilateral indicators need to be considered.

Additional key words: trade policy; NTMs; policy harmonization; trade agreements

Abbreviations used: CETA (comprehensive economic and trade agreement); EU (European Union); FTA (free trade agreement); HS (harmonized system); HS2 (harmonized system 2-digit level); HS6 (harmonized system 6-digit level); MRL (maximum residue limit); NTMs (non-tariff measures); RI (regulatory intensity); RIG (regulatory intensity gap); RO (regulatory overlap); RRI (relative regulatory intensity); RS (regulatory scope); RTA (regional trade agreement); SI (similarity index); SPS (sanitary and phytosanitary measures); TBT (technical barriers to trade); TRAINS (trade analysis information system); WTO (World Trade Organization)

Authors' contributions: AIS conceived the idea and obtained competitive funds. Both authors computed the indicators, discussed the results and wrote the final manuscript.

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Introduction

Increasing agricultural trade raises concerns about food safety as supply food chains become more interconnected, the risks of diseases or pathogens crossing borders increase, and doubts on the stringency of requirements on residues from pesticides, food additives or drugs, emerge (Harrus & Baneth, 2005; Sofos, 2008; Aarestrup *et al.*, 2008; Boqvist *et al.*, 2014; Perrings, 2016). These risks affect the livelihood of those depending on the livestock sector, can have a disruptive effect on the domestic and international markets, and require trade policy measures that address food safety without imposing unnecessary trade restrictions (Junker *et al.*, 2009; Knight-Jones & Rushton, 2013). Countries wishing to engage in the trade of animal products adopt sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT) to safeguard animal and human health, as well as the environment, which globally are guided by the basic rules or code of practice established in the SPS and TBT agreements of the World Trade Organization (WTO). Both WTO agreements aim at reconciling food safety with a minimum of trade restrictiveness, providing the mechanisms for dispute settlement and transparency on the implementation of standards (WTO, 2018a,b).

SPS regulations aim at protecting the health of flora, fauna and humans, by restricting or prohibiting the use of substances, imposing hygienic requirements or norms to prevent the dissemination of diseases (*e.g.* quarantine). TBT measures, on the other hand, relate to product, process and production methods characteristics, such as technical specifications and quality requirements, as well as labelling, marking and packaging, that aim at the protection of the environment, consumer safety and information[1]. Both SPS and TBT also include conformity assessment measures, such as certification, sampling, testing or inspection requirements to guarantee the fulfilment of the SPS/TBT regulations (UNCTAD, 2019).

SPS and TBT measures belong to the so-called "technical measures", and are particular non-tariff measures (NTMs), broadly defined as: "policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2010). Therefore, a certain degree of trade distortion is expected, but the technical complexity and variety of NTMs make it hard to identify if they pursue legitimate domestic goals, such as that of food safety, or rather aim at protecting domestic producers from external competition. Moreover, governments may impose poorly designed or targeted NTMs, without any protectionist intention, which may raise trade and producing costs and subsequently prices faced by consumers (Swinnen, 2017).

Removal of protectionist NTMs and alternative policy approaches, such as harmonization, would ease the burden on exporters while still being effective in addressing food safety. For this reason, most frequently, regional trade agreements (RTAs) include provisions related to NTMs, in particular, clauses encouraging harmonization and mutual recognition of standards (Ederington & Ruta, 2016). Piermartini & Budetta (2009) found such provisions on fifty-eight out of seventy RTAs surveyed. Examples of such RTAs are most of the bilateral RTAs where the European Union (EU) is involved. Cadot & Gourdon (2016) combined the information on technical provisions in RTAs by Piermartini & Budetta (2009) with the trade analysis information system (TRAINS) NTMs database (UNCTAD, 2017a) to evaluate the cost-saving effect of the so-called deep integration clauses (*i.e.* harmonization, mutual recognition, and conformity assessment). Previous work by De Frahan & Vancauteren (2006) addressed the cost-saving effect of standards harmonization in the intra-EU agrifood market.

Deeper regional integration requires a better understanding of NTM dynamics, for which some metrics have been proposed to guide policymakers. Winchester *et al*. (2012) proposed a "heterogeneity" indicator, applied to the EU and major trade partners in a few agro-food sectors, using own collected SPS data. Similarly, Ferro *et al*. (2015) proposed a bilateral restrictiveness indicator based on an own built database on maximum residue limits (MRL) of pesticides in around 60 countries and affecting fruits and vegetables. The TRAINS NTMs database provides a global overview of NTMs prevalence across food products and countries (the so-called inventory approach) (*e.g.* Gourdon, 2014) while bilateral indicators measuring the degree of similarity of patterns of NTMs applied by different countries have also been recently proposed. Cadot *et al*. (2015) defined a bilateral NTM distance indicator; UNCTAD (2017b) additionally introduced a regulatory overlap indicator, and Cadot *et al*. (2018) defined a similarity index based on the original proposal by Cadot *et al*. (2015).

Building upon this literature, we narrowed the sectoral focus which allowed us to go deeper into the SPS and TBT regulatory patterns and their similarity between selected countries. Our objective, though, remains in the descriptive field, without attempting to estimate the trade impact of existing NTMs and their convergence. Thus, in this paper, we make extensive use of the most recent release of the TRAINS NTMs database (UNCTAD, 2017a) to identify the SPS and TBT measures that regulate pork trade. We propose a new unilateral indicator that combines regulatory intensity and diversity and emphasize the use of bilateral regulatory similarity indicators which, with a few

[1] As an example, a compulsory regulation on animal welfare or nutritional label is a TBT, while a requirement on alergens labelling is SPS. In the case of consumers' safety regulations, these are classified as TBT unless they affect food. Thus, a safety regulation on toys materials is a TBT, while the restriction of certain materials in food packaging is an SPS.

exceptions, have usually been neglected in trade impact analysis. These bilateral indicators become crucial to evaluate the degree of stringiness of NTMs as the additional compliance cost to meet foreign regulations reduces when similar measures already regulate the domestic market. Given the weight of the EU in international markets and its active role in the promotion of bilateral RTAs, we put a special emphasis on the bilateral regulatory similarity between the EU and major trade actors.

Pork meat is one of the most intensely traded food products worldwide (around 40%, according to UN Comtrade (2018) database). Advancements in technology and the efficient feed conversion rate has enhanced pork production (FAO, 2018), which together with trade liberalization and growing demand in emerging economies, are expected to lead further increases in production and trade in the medium run (OECD-FAO, 2016). Simultaneously, the sector has witnessed recurrent disease outbreaks, the most recent examples being the African swine fever in China (FAO, 2018) and some Eastern European countries (DEFRA, 2018), as well as increasing citizens' concerns about animal welfare mainly in developed countries. The pork sector has also been subject to specific trade concerns. Of particular relevance is the dispute between the United States (USA) and the EU in relation to the use of ractopamine in feed, forbidden in the EU and other countries like China, but widely spread in the USA, with the consequent trade diversion. Thus, in the period 2012-2015 the USA import share in the Chinese market fell from 43 to 18%, while the EU share increased from 44 to 70% (own calculations based on Comtrade data). These are examples of concurring forces that demand for policy actions to address societal demands with minimum trade frictions.

Material and methods

The TRAINS NTMs database

The TRAINS NTMs database (UNCTAD, 2017a) is an inventory of public mandatory requirements enacted by official laws or regulations, retrieved from governmental sources. The requirements are then classified into 16 chapters (identified with letters), further sub-divided into 177 sub-categories of 4-digits (UNCTAD, 2019).

Therefore, the TRAINS NTMs database provides a rich picture of trade regulations, comparable across countries (up to 57 countries, with the EU included as a single entity), and detailed at 6 digits of the Harmonized System nomenclature (HS6-digit) (see Melo & Nicita, 2018, for a comprehensive review on alternative data sources). From the 16 chapters of NTMs, we single out SPS and TBT measures (Chapters A and B), which are the most frequent in food trade. For the purpose of this study, the pork sector comprises 18 HS6 lines, which fall into three chapters at HS2 aggregation: 02 "meat and edible meat offal" (13 HS6 lines); 05 "guts, bladders and stomachs of pigs" (1 HS6 line); and 16 "preparations of pork meat" (4 HS6 lines).

Within the range of 57 countries for which NTM data is available, we focus on the ten biggest importers, which jointly account for 95% of world pork trade value (88% excluding intra-EU trade) (UN Comtrade, 2018). The EU ranks first (56% of world imports) although most trade is intra-EU and only around 6% originates from third countries. The second largest importer is Japan (15%), followed by Russia (8%) and China (6%). The remaining importers highlighted are USA (4%), Canada (3%), Australia (1.3%), Singapore, New Zealand and Brazil (jointly accounting for 1.4%). The EU is also one of the biggest exporters of pork, ranking second after the USA (14 and 16%, respectively excluding intra-EU trade). The main destinations of EU pork are also the biggest importers worldwide: China (37% of extra-EU exports), Japan (27%) and Russia (15%), although exports to Russia have witnessed yearly declines.

Methods

We calculated two sets of NTMs indicators: unilateral indicators, which take into account the perspective of the importer, and it is the usual approach describing the incidence of NTMs; and bilateral indicators, which are more novel and focus on the degree of similarity or dissimilarity in regulations between the importer and exporter.

Unilateral indicators of NTMs incidence

Following Gourdon (2014) and UNCTAD (2017b) we calculated the regulatory intensity and regulatory scope, and by combining both, we propose a relative regulatory intensity index. The literature also reports frequency and coverage ratios calculated for each importer and defined as the percentage of traded HS6 lines and trade value, respectively, covered at least by one NTM. Given the narrow definition of our sector, we obtained 100% ratios for each country, meaning that there is at least 1 NTM affecting each HS6 line or traded value.

The *regulatory intensity (RI)* counts the number of measures *Nm* that the importer *j* imposes on product *h* (HS 6-digit line), adding up those corresponding to different NTM subcategories *k* (at 4-digits*):*

$$RI_h^j = \sum_k Nm_{h,k}^j \quad (1)$$

In general, the measures reported by an importer *j* apply to any exporter, but still, some measures can apply to specific partners. This is the case, for instance, of temporary prohibitions due to disease outbreaks. We will take into account this bilateral dimension only with the purpose of identifying measures affecting specifically the EU.

The *regulatory scope (RS)* counts the number of different subcategories *k* of NTMs (at 4-digits) applied to product *h* by importer *j*:

$$RS_h^j = \sum_k d_{h,k}^j \quad (2)$$

where $d_{h,k}^j$ is a dummy variable that values 1 when importer *j* applies at least one non-tariff measure of subcategory *k*, in sector *h,* and 0 otherwise.

Both, RI and RS can be averaged over the number of HS6-digit product lines in the selected sectoral aggregation (*i.e.* in our definition of Pork we have 18 HS6-digit products) to provide a figure per country. Likewise, we got specific indicators for SPS and TBT by restricting the sums in (1) and (2) to the number of subcategories within each NTM chapter.

A higher number of measures from a larger pool of NTM categories are expected to represent a higher regulatory burden. The rationale is that measures within the same subcategory are similar in nature and thus often impose relatively less burden (*i.e.* low RS) than measures from different categories (*i.e.* high RS) (Gourdon, 2014).

To account simultaneously for both dimensions of regulation, the number of measures and the number of different categories applied, the *relative regulatory intensity (RRI)* is proposed:

$$RRI_h^j = \frac{\sum_h RI_h^j \cdot RS_h^j}{\sum_h max_j\left(RI_h^j\right) \cdot max_j\left(RS_h^j\right)} \quad (3)$$

where the denominator selects, for each sector *h*, the maximum values for RI and RS found amongst the countries available in the NTM database, and adds up their product over sectors *h*; the numerator is the product of both indicators for a single country *j*. Thus, the higher the RRI index, the higher the regulatory burden in country *j* in comparison with the maximum possible in the sample of countries (*i.e.* multiplying by 100, it can be interpreted as percent over the maximum recorded). Likewise, two countries with equal RI will score differently in RRI depending on the number of categories of NTMs covered.

Bilateral indicators of NTMs similarity

Unilateral indicators provide the first insight into cross-country differences regarding NTMs application. Notwithstanding, the easiness of complying with specific rules set up by an importer will also depend on how close those rules are to those already in place domestically in the exporting country, which in the absence of origin discrimination, will be the same as those that the exporting country imposes to its imports (UNCTAD, 2017b). Besides, cross-country convergence or harmonization will be easier in light of already closer patterns of NTMs applications. To illustrate how similar the regulations are, we calculate three bilateral indicators.

The *similarity index (SI)* was introduced by Cadot *et al*. (2015) and has also been applied by UNCTAD (2017b) and, with small changes, by Cadot *et al*. (2018) and Melo & Nicita (2018). For each pair of countries *i* and *j* and product line *h* the SI is calculated as:

$$SI_h^{ij} = 1 - \frac{1}{K}\sum_{k=1}^{K}\left|d_{h,k}^j - id_{h,k}^i\right| \quad (4)$$

where $d_{h,k}^j$ is a dummy that values 1 when the importer *j* applies at least one NTM of subcategory *k* (defined at 4-digits), to product *h*, and 0 otherwise; $id_{h,k}^i$ accounts for the presence of NTMs of subcategory *k*, in product *h*, applied by exporter *i*; *K* is the number of NTM subcategories (at four digits) applied by any of the two countries.

SI ranges from zero when one country does not apply any measure on any subcategory while the other country applies measures in all possible subcategories; to one when both countries apply measures in the *K* subcategories of NTMs. The closer the indicator SI is to 1, the closer is the regulatory pattern between both countries, as the higher is the number of NTMs subcategories with a coincidence in the application. Expression (4) multiplied by 100, can also be interpreted as the percentage of NTM subcategories where there is a coincidence in the pattern of NTMs applied by the exporter *i* and importer *j*.

We also define the *regulatory intensity gap (RIG),* inspired by the work of Ferro *et al*. (2015) in the context of MRL, where both the type of substance (*i.e.* NTM subcategory in the context of the current NTM dataset) and the specific limits (*i.e.* number of measures) are considered; and built as an extension to the

SI indicator. Thus, if instead of dummy variables for the presence of NTMs as in (4) we use the RI or number of measures *Nm* as in (1), we get:

$$RIG_h^{ij} = \frac{1}{K}\sum_{k=1}^{K} Nm_{h,k}^{j} - iNm_{h,k}^{i} \tag{5}$$

That is, the RIG is the difference in the number of measures applied by the exporter and importer, to each product *h*, averaged over the full number of NTM subcategories *K* applied either by the importer or the exporter. RIG is not bounded; a positive (negative) number indicates that the importer *j* imposes a higher (lower) number of measures than the exporter *i*, on average across subcategories.

The *regulatory overlap (RO)* introduced by UNCTAD (2017b) measures the proportion of NTM subcategories (at 4-digit level) applied by the importer that is also applied by the exporter to each product *h*:

$$RO_h^{ij} = \frac{\sum_{k=1}^{K} d_{h,k}^{j} \times id_{h,k}^{i}}{\sum_{k=1}^{K_j} d_{h,k}^{j}} \tag{6}$$

The product of both dummies in the numerator will be either zero when NTM subcategory *k* is not shared by the importer *j* and exporter *i*, in sector *h*, and one otherwise. Adding up, the numerator is the number of NTM subcategories that both, importer and exporter, share. The denominator indicates the number of NTM subcategories applied by the importer *j* in sector *h*. The RO can vary between zero and one, from total lack of coincidence to perfect overlap. If the importer does not apply any NTM, the denominator is zero, and the formula is not defined. In this case, RO is replaced by one, as the exporter does not need to face any additional regulation to update their products or processes to access market *j* (UNCTAD, 2017b, p. 24). Both, SI and RO should move in the same direction, although they are not strictly the same. The RO considers the type of measures imposed by the importer and then checks if the exporter applies them or not. In the SI, simply the fact of sharing a type of measure is considered, irrespectively if the exporter or the importer applies it. As a consequence, differently from SI, the RO for a particular route and sector is not symmetric, as the number of different subcategories of NTMs may differ between countries *i* and *j*.

In principle the higher the RO or SI the easier the compliance with foreign regulations will be for the exporter. Nevertheless, still within the 4-digit NTM subcategory definition, there is a substantial degree of heterogeneity on specific measures. A clear example is MRL. Both trade partners may apply measures of this type (subcategory A210), contributing to a higher value in the Similarity and Overlap indexes, and reducing the distance in the RIG. However, the strict limits (*i.e.* parts per million) as well as which residues are constrained (*i.e.* veterinary medicines, antibiotics, pesticides) may differ substantially between both countries. All three bilateral indicators can be calculated for chapters of NTMs, for instance, SPS or TBT, simply updating the indicators *K* and *Kj*. Likewise, to provide a single figure for each bilateral relation, the indicators are averaged over HS 6-digit lines.

Results

Unilateral indicators

Regulatory intensity

For contextualizing purposes, Fig. 1 presents the RI of NTMs in pork meat trade (as defined in Eq. 1) and other agro-food sectors, broadly classified into: “ani-

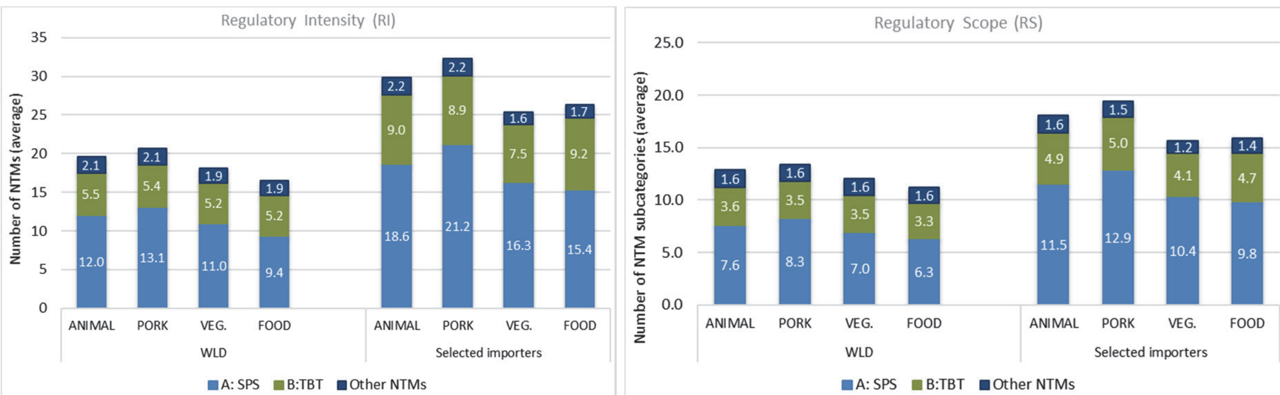

Figure 1. Regulatory intensity (RI) and regulatory scope (RS) of NTMs regulating the international trade of agro-food sectors. RI and RS represent the average per HS 6-digit line and reporter; the number of reporters is 57 (WLD) or 10 (selected importers). *Source:* Own elaboration based on data from UNCTAD (2017a).

mal" (HS2 chapters 01-05); "vegetable" (chapters 06-15); and "food" (chapters 16-24). Both "animal" and "food" exclude those HS 6-digit lines that enter in the composition of the pork sector. The average number of measures is presented for SPS, TBT and Other NTM chapters affecting imports (*i.e.* excluding chapter P). Also, for comparison purposes, the indicators are calculated for all countries in the database (57) and the ten selected main importers.

With independence of the geographical coverage, the RI in pork is the highest, with a total of 21 measures, around one more than other meats. Vegetable and food processed products face, on average, 18 and 17 measures, respectively. As reported by other studies (*e.g.* Gourdon, 2014), the data confirm the prevalence of chapter A (SPS) measures in all agri-food product groups, followed by chapter B (TBT). SPS measures, in particular, are slightly more prevalent in meat sectors (around 12-13 measures) than in vegetables (11 measures) or other food (9 measures). The average incidence of TBT measures, on the other hand, is very similar across these aggregate agri-food sectors (around 5 measures). Interestingly, the level of regulation raises substantially amongst the main importers in all broad sectors. For instance, on average, the pork sector is affected by 11 more measures in the selected importers than worldwide.

All pork product lines in the selected countries are affected by at least one technical measure (SPS or TBT), and consequently, all actual and potential trade is affected. Fig. 2 presents the average RI for SPS and TBT measures imposed by the top ten importers. The calculations distinguish between those measures that affect any trading partner and those addressed to the EU in particular, either as a single entity or specific EU countries.[2] Per country, SPS measures also predominate over TBT. Amongst the ten top importers, USA and Australia are the countries with a more intense regulation on technical NTMs, applying on average (per HS6 product), 39 SPS/16 TBT and 27 SPS/17 TBT measures, respectively. The EU occupies an intermediate position, with 18 SPS and 4 TBT measures, while China is the least regulated regarding both, SPS (12 measures) and TBT (3 measures).

In comparison, Brazil and Canada present a closer use of SPS and TBT regulations (18 SPS, 15 TBT, and 16 SPS, 13 TBT, respectively). The collection process to build up the NTMs database is common across countries, but more transparent and comprehensive legislation and the presence of different domestic legislative sources may lead to an apparent higher RI in some countries (*i.e.* the USA provides detailed information on partial coverage of HS6 products). Therefore, although useful, we still need to be cautious with cross-country comparisons (see UNCTAD 2017b, p. 14 for a detailed account of data limitations).

Half of the countries selected apply specific measures to the EU. It is important to note, however, that these NTMs do not necessarily affect all EU members or all pork product lines equally. For example, the USA applies an SPS traceability requirement (A859) to only three EU countries (Cyprus, Croatia, and Malta), and two HS6 products (160100 and 160249). Examples of specific regulations by the USA affecting most or all countries in the EU and most or all product lines are requirements on the production (*e.g.* A630 on food and feed processing, A640 on storage and transportation conditions) and conformity assessments (*e.g.* A830 on certification requirements, A840 on inspections by the importing country). Another example is a temporary geographic prohibition for SPS reasons imposed by China to the EU (A110), following concerns of the presence of the African swine fever, and affecting Germany, Belgium, Greece and the Netherlands. This measure was initiated in 1994-1998 and was still in force in 2012, the year of the data collection. Japan also records temporary prohibitions (A110) to 20 EU members, initiated in 2014-2015, and requirements on cold/heat disinfection treatments (A510), which affect 12 EU countries. Finally, Russia reports specific authorization requirements for SPS reasons (A140) to all EU member states.

Regulatory scope

In the NTMs database, there is a pool of 42 4-digit NTM subcategories within the SPS chapter and 28 within the TBT chapter affecting agro-food products. From these, 35 SPS and 22 TBT subcategories are reported in pork by some of the ten main importers. In Fig. 1 the RS or number of different NTM subcategories at 4-digit, for pork, other animal products, vegetables and processed food is presented. The scope of NTM subcategories applied is slightly larger for pork than other food products, and the ten selected importers make use of a broader range of NTM subcategories than worldwide in each broad sector. Thus, on average,

[2] Calculating the average RI strictly over the lines actually traded has a negligible impact on the average figures in Fig. 2, and only on those four countries that trade in less than the 18 product lines: Australia and China (15 lines); Brazil (12); and Singapore (17). Empirically, for the purpose of this analysis, a reporter is considered to trade in a product line if the mean value of imports in the period 2012-2016 in such product is positive.

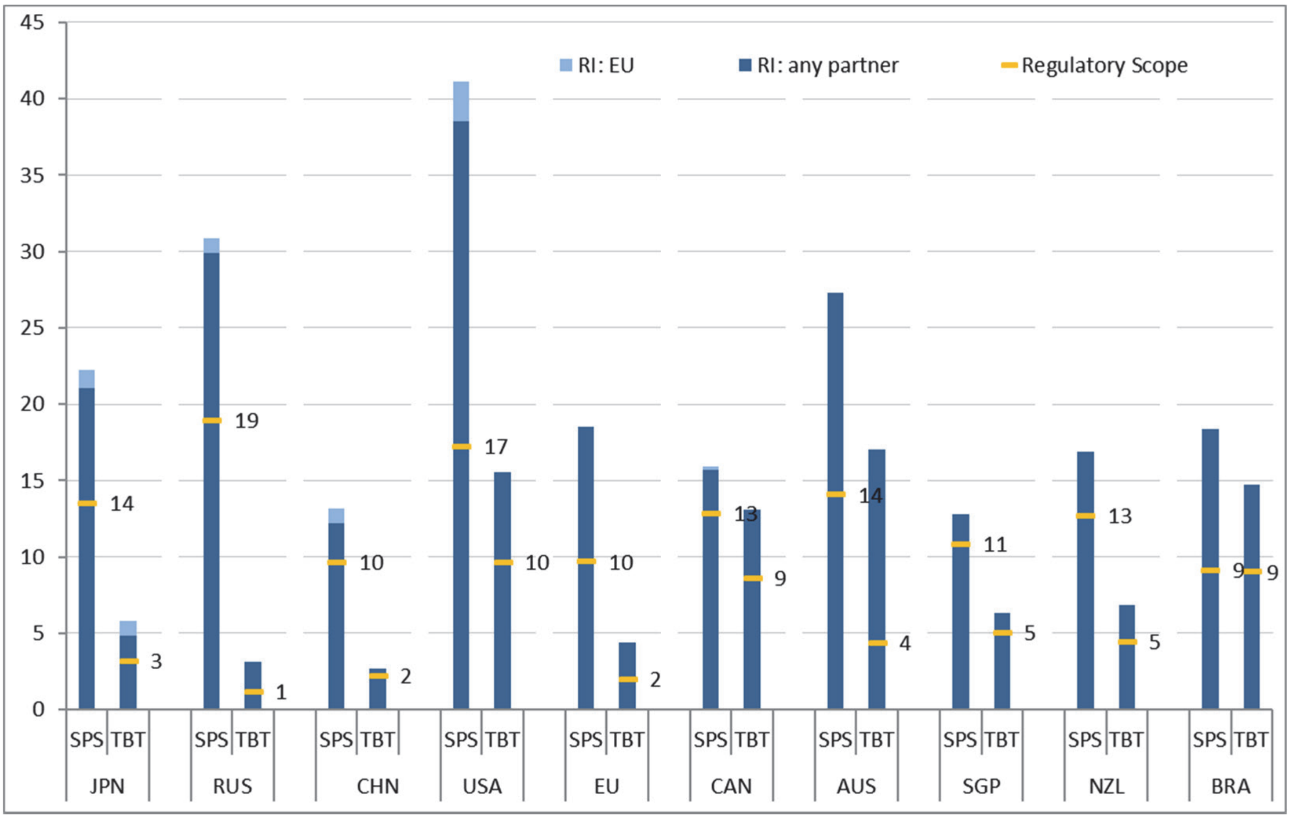

Figure 2. Regulatory intensity (RI) and scope (RS) of technical regulations (SPS, TBT) in pork trade. RI (number of measures) on average per HS 6-digit line. Dark and light blue bars indicate RI affecting, either any trading partner or specifically the EU (all or some EU member states). The yellow markers show the average RS (number of 4-digit NTM subcategories) applied by the reporter to any partner, on average per HS 6-digit product. Mean RIs for SPS (also for TBT) are statistically different ($p<0.01$) across countries according to the Welch's test, robust for unequal variances (confirmed with the Levene test). The countries in the x-axis are sorted according to import weights, in descending order. *Source:* Own elaboration based on data from UNCTAD (2017a).

each country in the available sample applies around 13.4 different NTM subcategories (8.3 of which are SPS) on each pork product line, while this figure goes up to 19.5 amongst the ten main pork importers.

The average *RS* applied by each reporter within the SPS and TBT chapters is shown in Fig. 2, and the specific list of NTM subcategories is listed in Table S1 [suppl.]. Amongst the top 10 importers, USA makes use of a broader range of technical measures (27 categories, adding up SPS and TBT), followed by Canada and Russia (22 and 20 categories). The EU and China, on the other hand, are the regions with a narrower range (12 categories).

It is interesting to note that almost all (9 out of 10) selected countries apply 4 out of the 35 SPS subcategories and all 10 countries apply 1 out of 22 TBT subcategories (last column in Table S1 [suppl.]). In other words, there is much variety in the application of technical regulations across countries and only a few of them are uniformly applied. These are related to MRL of non-microbiological contaminants (A210), restricted use of certain substances in food, feed and their containers (A220), labelling requirements in relation to food safety (A310) or other aspects of the design and contents of the label itself (B310), and inspection requirements to be performed in the importing country (A840). The range of sectors affected also varies significantly across NTM subcategories, while the coverage by the five more prevalent subcategories affect most or all of the pork product lines.

Given the high dispersion in the use of SPS measures at the four-digit level mentioned above, we aggregate RI and RS at the two-digit level. Results are presented in Table S2 [suppl.]. Subcategories A2, A4, and A8 are employed by all main importers, with different intensities. On average, over the ten main importers, A8 registers the highest RI (6 measures per product) and RS (4 subcategories), followed by A2, that covers on average two different subcategories and four measures per product. A8 relates to the verification procedures required to assess that certain SPS measure has been met, including certification of conformity with a specific regulation (A830) and inspection procedures in the importing country (A840); and A2 measures regulate the tolerance limits for residues (A210) and restrict the use of certain substances (A220) (UNCTAD, 2019).

On the other hand, A4, also applied by all the leading importers, are hygienic requirements on the product (A410) or production processes (A420). Other three categories, A1, A3, and A6, are applied by nine of the ten main importers selected, and include, on average, 2 subcategories and 3 measures per product. A1 includes temporary prohibitions (A110), geographical restrictions such as imports can only come from countries and establishments in a positive eligible list (A120) or special authorizations and permits (A140) for SPS reasons. A3 includes labelling, marking and packaging requirements such as the inclusion of production date and quality guarantee period (A310). A6 are other requirements on production or post-production, not covered in detail by other subcategories of SPS, for instance, related to food and feed processing (A630) or storage and transport conditions, including substances and materials of the containers (A640).

Relative regulatory intensity

The RRI is calculated for each country using equation (3) and results for the key importing countries are presented in Table S3 [suppl.]. The RRI positions the USA as the country with the more relative regulatory burden in pork trade (0.86), although the cautionary message elicited above also applies here (*i.e.* some countries provide more transparent and comprehensive legislation). Russia ranks second, but only concerning SPS measures, as TBT are hardly applied. Four countries record SPS RRI Indexes in the range 0.20-0.30 (Brazil, EU, Canada, and New Zealand) while China ranks last (0.14). Regarding TBT, however, the dispersion of the RRI index is broad, ranging from 0.02-0.05 in Russia, China, and the EU to 0.86 in the USA. Considering all three unilateral indicators for SPS measures altogether, the ranking of the USA, Russia, Australia, and Japan remains unaltered. In other words, these are the four countries with most SPS regulations according to any of the three indicators (RI, RS, and RRI). Singapore and China show the lowest scores in the three indicators. Canada and New Zealand, on the other hand, appear as more regulated using the RRI index than the isolated RI would suggest.

As noticed above, countries make different use of SPS and TBT measures, depicting regulatory patterns that lead to a burden in general, entirely different across these two broad types of NTMs. In order to have a global index for the ensemble of technical measures, we apply equation (3) but aggregating both, SPS and TBT measures. The resulting ranking of the relative regulatory burden is presented in the fourth column in Table S3 [suppl.], while the equivalent calculation for the full pool of NTMs (other than chapter P) is also presented in the last column. The USA remains at the top, but Canada and Brazil, with more modest use of SPS measures, rank higher due to the more intense TBT use (values of RRI between 0.41 and 0.56). The EU gets closer to Singapore and China when considering both, SPS and TBT measures, scoring at the lowest spectrum of the RRI scale. Still, any selected principal importer shows a relative burden above the mean of the remaining 46 countries in the database (mean RRI is 0.13). When comparing RRI calculated over the aggregate of SPS and TBT measures with the full aggregation of NTMs, the ranking is identical, as most of the NTMs applied in pork fall into the SPS/TBT categories.

Unilateral indicators and their relationship with trade, tariffs and GDP

As a final inquiry, we cross-reference each unilateral indicator with the value of imports and tariffs, as an initial approximation to two underlying common hypothesis in the trade literature: countries and sectors more exposed to trade tend to regulate more in response to food safety and other societal concerns (Trefler, 1993); and NTMs are replacing tariffs as protectionist measures (Aisbett & Pearson, 2012; Beghin & Xiong, 2016; Niu *et al*., 2018). The econometric and graphical analysis conducted by Kee *et al*. (2009) and UNCTAD (2018) respectively, have shown some evidence in favour of this latter hypothesis.

Furthermore, previous research (Kee *et al*., 2009; UNCTAD, 2018) suggests that wealthier countries tend to make more use of technical measures (SPS and TBT) while it is somewhat the opposite for other types of NTMs. As economies grow richer consumers demand more product variety, quality and safety. And to guarantee superior levels of quality and safety, more SPS/TBT regulations are needed. Thus, Kee *et al*. (2009) found a positive correlation between the ad-valorem equivalents of technical NTMs and GDP per capita. However, as they also find that richer countries tend to impose lower tariffs, the overall level of protection (NTMs plus tariffs) decreases with GDP per capita.

In the current application, a positive and significant correlation is found between imports (2012-2016 mean based on UN Comtrade, of the 57 available countries) and each of the uni-lateral indicators, although not of significant magnitude. In other words, countries apply more SPS measures (and more variety of categories) on those product lines more intensely traded and countries that import more also regulate more (correlations in the range 0.09-0.11 $p<0.01$). On the other hand, the bivariate analysis between tariffs (2015 ad-valorem applied tariffs from TRAINS) and the unilateral indicators reveals significant and negative correlations for both, SPS and TBT measures, and positive (albeit non-significant) for other non-technical measures. Thus, for SPS measures, correlations are -0.09, -0.11 and -0.13 for RI, RS and RRI, respectively (p<0.01); and for TBT: -0.17,-0.09 and -0.21 (p<0.01). Accordingly, technical measures and tariffs move in opposite directions, and those countries and sectors with lower tariffs compensate by more intensive use of technical instruments, while non-technical measures tend to be accompanied by more restrictive tariffs. Splitting by income groups, the negative correlation with technical measures is maintained in high-income countries and reverses in low-income countries (although only in TBT the correlation is significant, -0.23 p<0.01 and +0.54 p<0.01). The use of technical measures is positive and significantly correlated with per capita GDP (correlations in the range 0.39-0.58, p<0.01, for RI, RS and RRI, in both, SPS and TBT measures).

In any case, the previous analysis has to be interpreted with caution, and more determinant conclusions on the relationship between NTM regulatory burden and tariffs, income and trade, would require first, a sufficiently large dataset (with a broader product representation) and second, a panel estimation model to control adequately for product and country-specific effects. Besides, the regulatory burden identified with the unilateral indicators would require an appropriate translation into ad-valorem equivalents (which is beyond the scope of this paper) for a more suitable comparison with other variables, tariffs in particular.

Bilateral indicators on regulatory similarity

We calculated three bilateral indicators for every possible pair of countries in the NTM database (*i.e.* 3192 pairs), but we will focus on the bilateral results for the selected key importers (Table S4) [suppl.], and in relation to the EU.

The SI in equation (4) is presented in Fig. 3, averaged over product lines and calculated for SPS and TBT measures. For comparison purposes, for each principal importer, the average with all 56 possible trade partners as well as with the EU is presented.

We can highlight three general results. First, the similarity of regulatory patterns between the EU and the remaining selected countries is relatively low, taking into account that, on average, only 15-35% of the pool of NTM subcategories (excluding chapter P) are shared. Second, although low, the similarity is higher with the EU than worldwide, in both, SPS and TBT. Given the geographical and income diversity of countries in the NTM database, it seems logical to find a closer affinity in regulations with one of the main actors in world pork trade, as it is the EU. And third, compar-

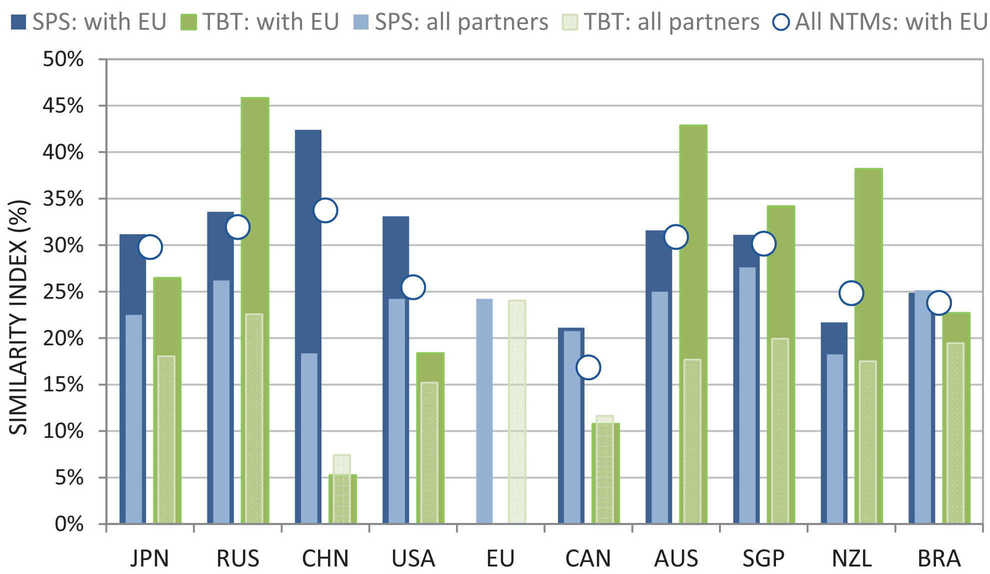

Figure 3. Bilateral similarity index (SI) of technical regulations (SPS, TBT) in pork trade for selected countries. SI is the percentage of 4-digit NTM categories shared by the country in the axis with the EU, for SPS (deep blue bars), TBT (deep green bars) and all NTM categories (white marker). The SI for all partners (light blue and green bars) was calculated over all available countries with NTM information (57 countries). All results were averaged over HS 6-digit lines. Countries in the x-axis are sorted according to imports weight, in descending order. *Source:* Own elaboration based on data from UNCTAD (2017a).

ing SPS and TBT measures, there is not a clear pattern in the degree of similitude. Thus, the bilateral similarity with the EU is higher in the SPS than in the TBT chapter in five countries, and TBT similarity is higher than SPS in the remaining four countries. When considering all possible pairs of SI instead of only those that affect the EU, however, the bilateral similarity is always higher for SPS than TBT (see light blue and green bars in Fig. 3).

On a country by country basis, the closest pattern of SPS measures with the EU is observed in China (around 42% of the 4-digit SPS subcategories are common), followed by USA (0.33), Australia, Singapore, Russia and Japan (around 30%). The SI in SPS measures between China and other key importers, such as the USA or Japan, is also relatively high (36 and 30%, respectively) (Table S4 [suppl.]). A relatively recent access of China to international markets and WTO accession (in 2001) may explain that the legislative body on SPS has been developed more in consonance with other important trade actors as the EU. This similarity, however, does not extend to TBT, where China stands out as the most dissimilar country with respect to both, the EU (only 5% of the subcategories are shared) and other countries (7% on average) (Table S4 [suppl.]). Other developed countries, like New Zealand and Canada, show a relatively lower degree of similarity of SPS measures with the EU, sharing only around 20% of the subcategories. In terms of TBT, after China, Canada is the country with the most different regulatory pattern from the EU (10%) (as it is the case with SPS measures), while in the other extreme, Russia and Australia have in common with the EU more than 40% of the TBT categories applied.

This bilateral dimension of regulation has usually been neglected in trade impact analysis but becomes crucial to evaluate the degree of stringiness of non-tariff measures in general, and SPS/TBT measures in particular. For instance, just looking at the unilateral indicators like RI and RS (Fig. 2), we see countries with relatively low RI and RS in SPS measures, like New Zealand or Brazil, but with a spectrum of NTM subcategories that differs substantially from the EU (*i.e.* only around 22-25% of SPS subcategories are shared). On the other hand, countries like the USA, which applies on average around 40 SPS measures across 17 categories, show a relatively more similar pattern (although still low) with the EU, sharing 33% of the SPS categories.

In Fig. 4, we present the average RIG (equation 5) between the EU (as exporter) and the selected key international markets, as well as with the full set of partners available in the NTM dataset. A positive (negative) number implies that the reported country imposes, on average across product lines and alternative NTM subcategories, a higher (lower) number of measures than the EU in their bilateral trade.

The RIG analysis suggests that it might be easier for the EU to access foreign markets than the other way round. When confronted with all possible trade partners, the RIG of both, SPS and TBT measures, is higher in the EU (last bars in Fig. 4). However, when compared with specific trade partners, we observe both, positive and negative values. For instance, China,

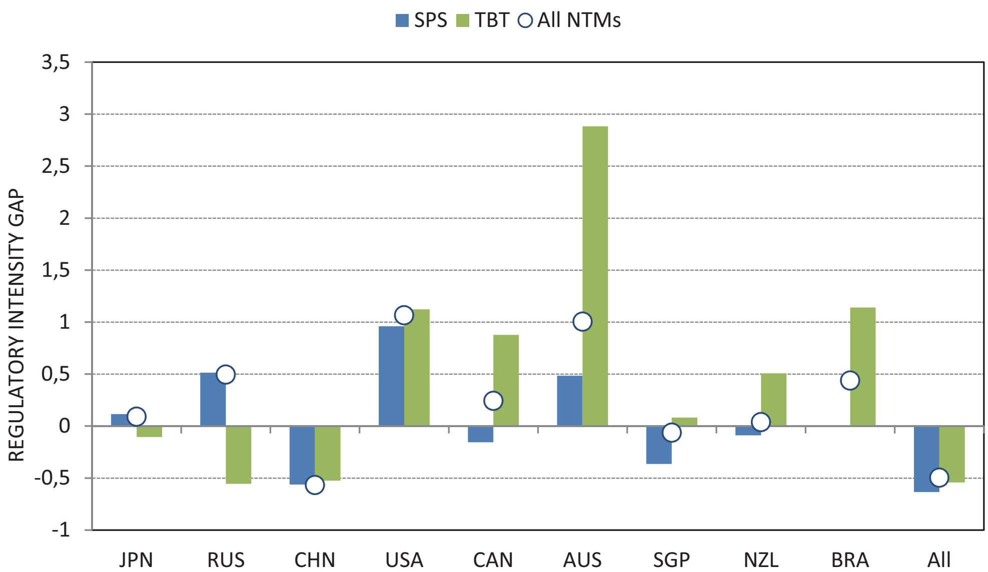

Figure 4. Bilateral regulatory intensity gap (RIG) of technical regulations in pork exported from the EU to key importers. Average over HS 6-digit lines; 'All partners' refer to all 56 possible trade partners available in the NTMs dataset. Countries in x-axis sorted according to imports weight, in descending order. *Source:* Own elaboration based on data from UNCTAD (2017a).

Canada, Singapore, and New Zealand face, on average, more SPS regulations when exporting pork to the EU than the other way round; USA, Australia, Russia or Japan, on the other hand, face fewer measures when exporting to the EU. In terms of TBT, some of the patterns are similar (USA, Australia, China) while in the remaining six countries, the RIG moves in the opposite direction to that one reported for SPS.

Finally, Fig. 5 shows the bilateral RO (equation 6) of SPS and TBT measures between the EU and the selected importers. As such, it presents, averaging over HS 6-digit lines, the percentage of SPS and TBT subcategories applied by those key markets that are also applied by the EU to its imports (and the domestic market).

The conclusions that arise from the RO are similar to those emanating from the SI, with the nuance that the RO percentages are more prominent, the implication being that a substantial percentage of the SPS and TBT subcategories employed to regulate pork imports by the selected countries is also applied by the EU to regulate its domestic or external demand. Thus, on average, around half of the pool of SPS/TBT categories applied worldwide is also applied by the EU. Across countries, the EU SPS regulations cover around 40% of the categories also employed by Japan, Russia, USA, Australia, Singapore or Brazil, and 60% of those imposed by China. The degree of SPS coverage drops substantially with Canada and New Zealand (30%), as well as concerning TBT measures with specific countries (China, USA, Canada or Brazil).

Finally, we found a positive and significant correlation (although of small magnitude) between the degree of similarity of the SPS and TBT regulatory patterns and bilateral trade (2012-2016 mean). Thus, pairwise correlations with the SI is 0.02 ($p<0.01$), the RO is 0.01 ($p<0.01$) and the RIG is -0.01 ($p<0.05$), in SPS measures. For TBT measures, correlation with SI and RO are 0.01 ($p<0.01$), and -0.01 ($p<0.01$) for RIG. These correlations augment slightly, to 0.05 in RS and RO, and -0.05 in RIG when constrained to the main ten importers.

Discussion

Technical NTMs, such as SPS and TBT measures are particular instruments aiming at guaranteeing that imported food meets domestic safety standards. However, the heterogeneity in both, the regulatory intensity and coverage of NTM subcategories that we have found, in particular in SPS measures, points out at potentially important trade frictions. Indeed, in the period 2000-2018, a total of 429 new specific SPS trade concerns were raised to the WTO, from which 36% were related to animal health and 33% to food safety (WTO, 2018c).

Some types of measures are more uniformly applied than others, and all main importers make use of MRL regulations (A2), hygienic requirements (A4) and conformity assessment procedures (A8). By taking into account both regulatory dimensions (RI and RS), our RRI analysis clearly identifies USA and Russia as the countries with the highest SPS regulatory burden, followed by Australia and Japan; New Zealand, Canada, the EU, and Brazil occupy an intermediate position; while China and Singapore are relatively less regulated.

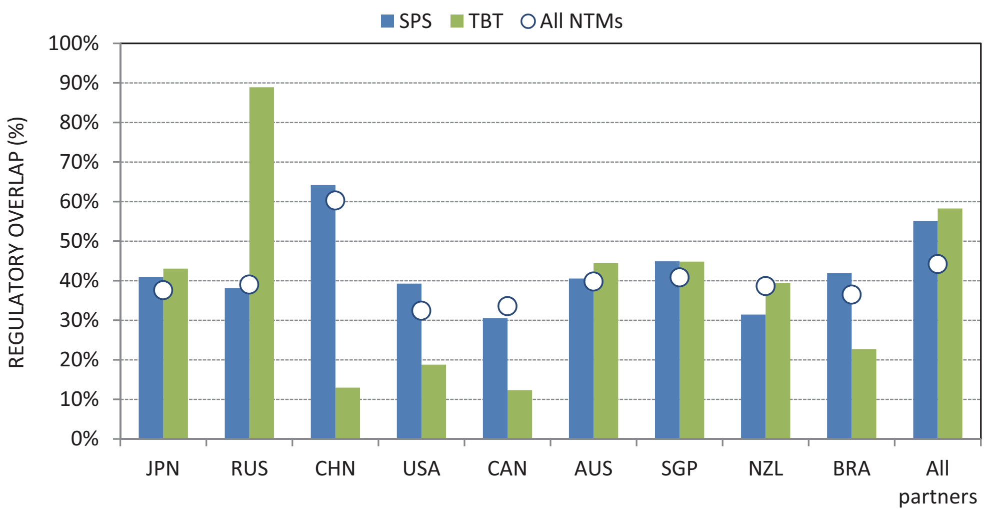

Figure 5. Bilateral regulatory overlap (RO) of technical regulations (SPS, TBT) in pork exported from the EU to key importers. Average over HS 6-digit lines. 'All partners' refer to all 56 possible trade partners available in the NTMs dataset. "All NTMs" exclude chapter P. Countries sorted according to imports weight, in descending order. *Source:* Own elaboration based on data from UNCTAD (2017a).

Tentatively, we found that SPS regulations in the pork sector increase with trade intensity, which is consistent with the notion that regulations are induced by safety concerns that are more likely raised in those sectors and countries more engaged in trade. However, an inverse relationship between tariffs and the unilateral regulatory indicators was also found, which would support the perception of NTMs as substitutes for tariffs in attaining protectionist goals, concurring with the more general trends observed by Kee *et al*. (2009) and Melo & Nicita (2018). Splitting by income groups, our results are also consistent with Kee *et al*. (2009) and Melo & Nicita (2018)'s appreciations on that GDP per capita is associated with a more intense use of NTMs and lower tariffs.

Some SPS/TBT measures are better suited for harmonization than elimination or reduction as they address legitimate food safety issues (UNCTAD, 2017b), while others can raise heated disputes under insufficient scientific evidence and/or opposed societal preferences (*e.g*. genetically modified organisms in feed, ractopamine in swine diets, growth hormones). Our results on the low similarity of SPS (30%) and TBT (20%) regulations, even at the aggregated level of the NTM subcategory analysed here, evidence the challenges faced to streamline technical regulations (especially SPS). In this sense, bilateral free trade negotiations may smooth the path through mutual recognition of the equivalences of technical measures. For instance, the CETA between the EU and Canada reached in 2017 contemplates the recognition of equivalence for specific SPS measures affecting meat trade (EC, 2018a). Similarly, the recently initiated (June 2018) negotiations for the fulfilment of an FTA between the EU and New Zealand (EC, 2018b) could also be the ideal setting for reducing the significant distance observed in SPS regulatory patterns (around 20%).

Our results on SPS similarity patterns for the pork sector share the tendencies observed for agriculture in general by Melo & Nicita (2018). Thus, these authors highlight the variance in the regulatory convergence across countries, pinpointing a closer regulatory framework between the EU and USA (index is 0.25 *vs* our 0.33), as well as a general tendency worldwide to be more aligned with EU regulations than the USA, highlighting China in particular.

Although with a simplistic statistical approach, we find that trade partners with fewer differences in their regulatory patterns tend to trade (slightly) more. These results point in the direction of harmonization as a way to trade-cost savings as found econometrically by Cadot *et al*. (2018) and Cadot & Gourdon (2016) in general; De Frahan & Vancauteren (2006) with respect to intra-EU agrifood trade, and UNCTAD (2017b) in the context of Mercosur.

Finally, our results show that the unilateral indicators may be misleading when aiming at establishing relevant trade costs for specific partners. For instance, despite the more intensive regulation in the USA than in Brazil, EU pork exporters may find much easier to comply with USA regulations thanks to a relatively higher degree of similarity in the regulatory patterns. Nevertheless, we need to acknowledge that still the similarity index is quite broad in its definition and the variety of instruments within each subcategory may still draw important trade concerns. For instance, Arita *et al*. (2017) pinpoint the use of beta-agonists by USA pork producers as a significant impediment to export to the EU. This specific measure would fall in the A210 SPS subcategory, which is shared by both, the EU and USA.

Some caveats need to be acknowledged that can lead to future research. First, cross-country RI measures are still subject to substantial domestic legislative differences. More detailed norms may lead to a more intensive regulation (UNCTAD, 2017b) that would require further refinements in the indexes definition. Second, the SI refers to categories of NTMs which in turn encompass different measures, and within each measure, specific requirements can differ. Therefore, similar regulatory patterns according to the indexes applied here are still compatible with certain degrees of diversity, which can turn into significant trade impediments, as explained above. In this sense, the TRAINS NTM database can still be used, by exploiting further the link to those documents that describe in more detail the specific measures. Third, although we tried to offer a better proxy for regulatory burden with the RRI, this is still a rough approximation for stringency, as all the measures and categories have equal weight, irrespectively of how difficult they are to meet. As Cadot *et al*. (2018) point out, a certain approximation to stringency is more straightforward in purely quantitative measures (*i.e*. MRL), and indexes have indeed been proposed by Li & Beghin (2014) and Ferro *et al*. (2015), while in others will remain subjective. Finally, the indicators are based on published regulations which, in principle, are expected to be implemented and enforced. However, this is unknown without deeper knowledge of the country and its law enforcement mechanisms.

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