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Farm to World: How Does Traceability Affect International Trade in Agricultural Products?

**Scarlett Queen Almeida Bispo, Fernanda Aparecida Silva, Michelle Márcia Viana Martins,
Marcelo José Braga Nonnenberg, and Ruan da Silva Vianna**

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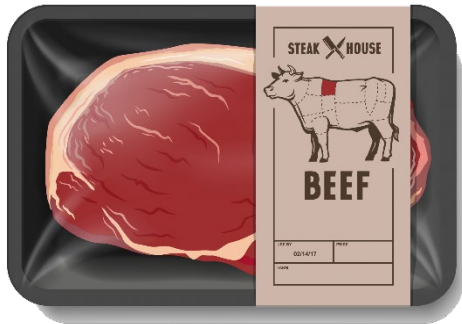
Farm to World: how does traceability affect international trade in agricultural products?

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Introduction

In the occasion of outbreaks of animal diseases or plant pests, traceability allows more effective control, preventing their spread, minimizing the negative impact of this outbreaks on the agricultural sector and the environment.

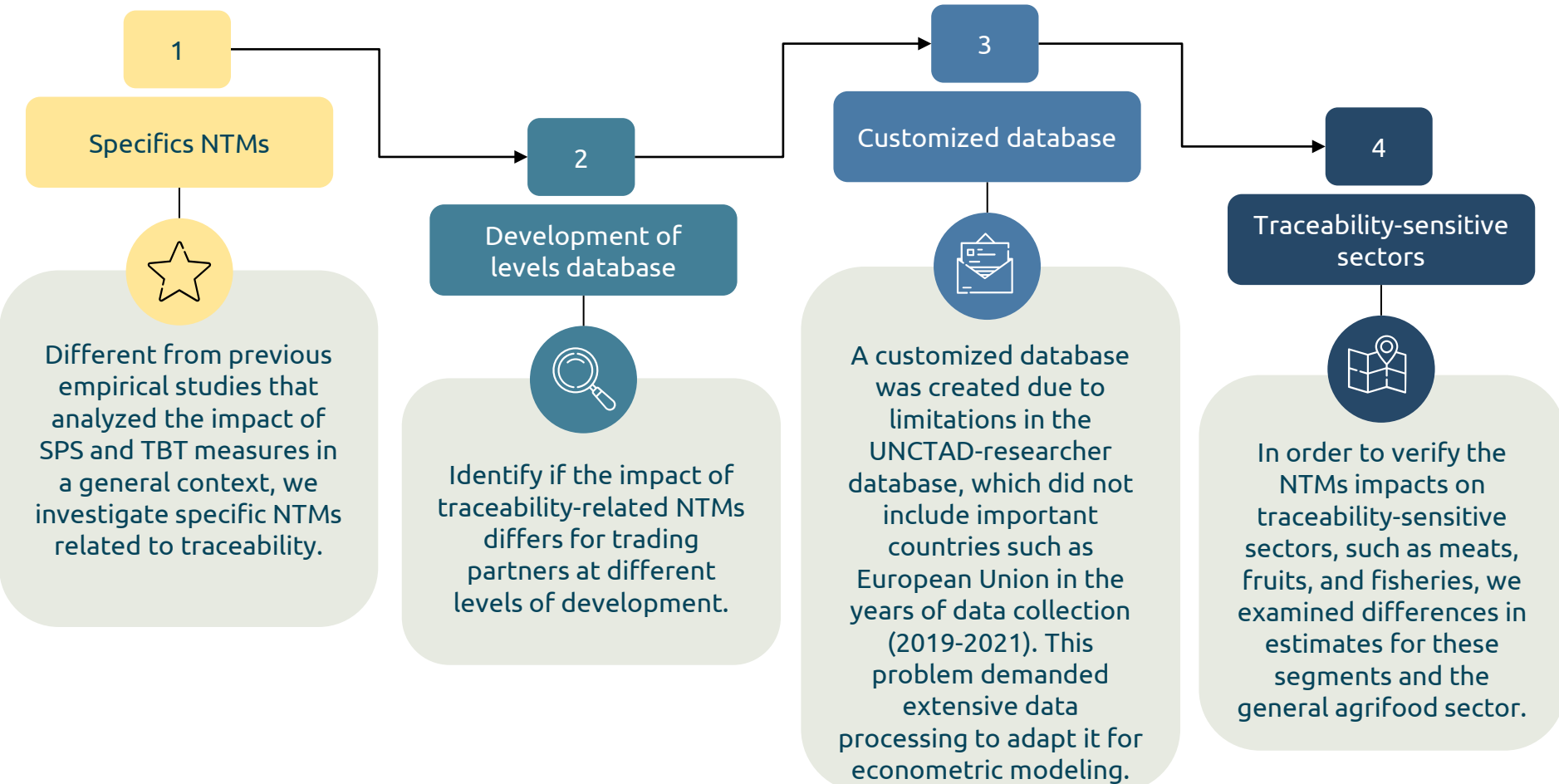


The International Organization for Standardization (ISO) defines traceability as the ability to track the path of a food or feed product through the various stages of the food chain.

Government agencies monitor food safety and protect the territory through non-tariff measures (NTMs). The UNCTAD provides information on each country's requirements, including traceability requirements, and categorizes them as technical NTMs.



Contributions and objective



Our study focuses on determining the **impact of traceability NTMs in 53 exporting and 58 importing companies, covering a total of 2,081 agribusiness products.**

Table 1. Disaggregation and description of traceability related NTMs.

NTMs code	NTMs description
A	SANITARY AND PHYTOSANITARY
	Provisions to protect human, animal, and plant health and the environment that address additives, contaminants, diseases, pests, and biodiversity. These measures include traceability requirements.
A8	Conformity assessment related to sanitary and phytosanitary conditions
A85	Traceability requirements
A851	Origin of materials and parts
A852	Processing history
A853	Distribution and location of products after delivery
A859	Traceability requirements not otherwise specified
B	TECHNICAL BARRIERS TO TRADE
	Technical regulations and conformity assessment procedures for product characteristics, production processes, labeling, packaging and marking requirements, including traceability.
B8	Conformity assessment related to technical barriers to trade
B85	Traceability requirements
B851	Origin of materials and parts
B852	Processing history
B853	Distribution and location of products after delivery
B859	Traceability requirements not specified elsewhere

Source: UNCTAD

The empirical model adopted in this study is based on the gravity model, estimated in this study in equation (1):

$$M_{ijkt} = c + \beta_0 fta_{ijt} + \beta_1 A85_b_{ijkt} + \beta_2 A851_b_{ijkt} + \beta_3 A852_b_{ijkt} + \beta_4 A853_b_{ijkt} + \beta_5 A859_b_{ijkt} + \beta_6 B851_b_{ijkt} + \beta_7 A85_m_{ikt} + \beta_8 A851_m_{ikt} + \beta_9 A852_m_{ikt} + \beta_{10} A853_m_{ikt} + \beta_{11} A859_m_{ikt} + \beta_{12} B85_m_{ikt} + \beta_{13} B851_m_{ikt} + \beta_{14} B852_m_{ikt} + \beta_{15} B853_m_{ikt} + \beta_{16} B859_m_{ikt} + \gamma_{it} + \delta_{jt} + \eta_{ij} + \tau_k + \varepsilon_{ijkt} \quad (1)$$

NTMs starting with A are SPS measures; and those starting with B are TBT measures.

Bilateral measures (with subscript "b") analyze the effect of traceability related measures targeted at specific trading partners.

Multilateral measures (with subscript "m") capture the effect of traceability related measures applied to all countries, without distinguishing the affected partner.

Table 2. Description and data source of the variables to be estimated using the gravity equation.

	Variable	Unit	Source
M_{ijkt}	Nominal value of imports of good k by country i from country j in year t . The subscripts i, j and k are respectively 58 importing countries, 53 exporters, 2,081 six-digit products according to the Harmonized System classification of agribusiness products according to the Ministry of Agriculture, Livestock and Food Supply of Brazil (MAPA, 2023) and t is the period between 2012 and 2021.	Current USD	UN CONTRADE - World Integrated Trade Solution (WITS)
fta_{ijt}	Dummy takes value 1, if countries i and j have a free trade agreement; 0 otherwise.	Binary	Mario Larch
$A85_{bijkt}$ $A851_{bijkt}$ $A852_{bijkt}$ $A853_{bijkt}$ $A859_{bijkt}$	Dummies take value 1 if importing country i imposes traceability related SPS measures on exporting country j for good k in year t ; 0 otherwise.	Binary	
$B851_{bijkt}$	Dummy take value 1 if importing country i imposes traceability related TBT measures on exporting country j for good k in year t ; 0 otherwise.	Binary	UNCTAD - The Global Database on Non-Tariff Measures (TRAINS)
$A85_{mikt}$ $A851_{mikt}$ $A852_{mikt}$ $A853_{mikt}$ $A859_{mikt}$	Dummies take value 1 if importing country i imposes traceability related SPS measures for good k in year t ; 0 otherwise.	Binary	
$B85_{mikt}$ $B851_{mikt}$ $B852_{mikt}$ $B853_{mikt}$ $B859_{mikt}$	Dummies take value 1 if importing country i imposes traceability related TBT measures for good k in year t ; 0 otherwise.	Binary	
$\gamma_{it}, \delta_{jt}, \tau_k, \eta_{ij}$	Importer-year (γ_{it}) and exporter-year (γ_{it}) fixed effects (FE), which control specific phenomena in each country and that vary over time; τ_k is the product EF and η_{ij} is the EF for the country pair, which controls for pair-specific phenomena that do not vary over time.	Econometric procedures	
ε_{ijkt}	Error term		

Source: Own elaboration.

The main recommendations for using the gravity model by Yotov et al. (2016):

1

We used panel data to estimate the gravity model

2

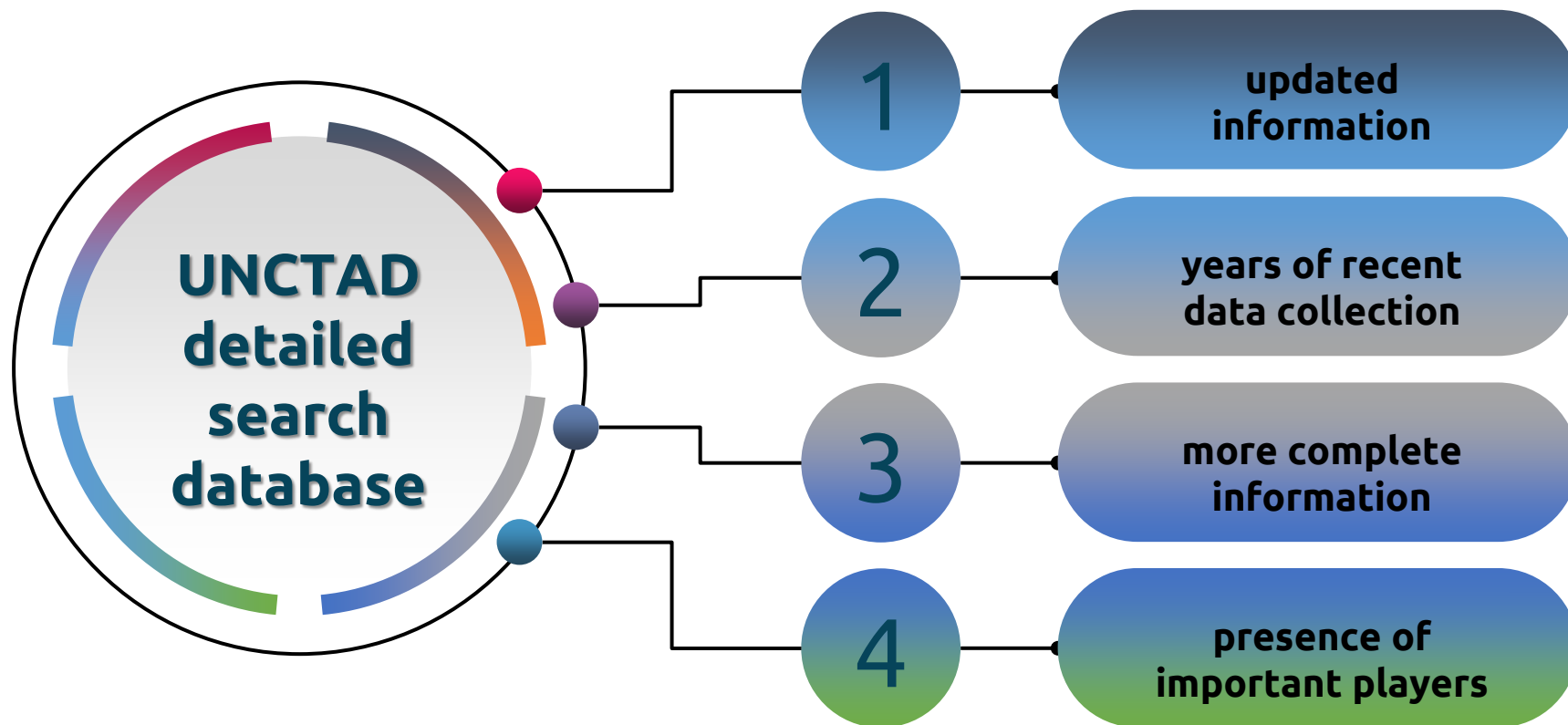
Used panel data with time intervals rather than consecutive years. We used 3 and 5 years, the last like We used 3 and 5 years. The model with 5 years was used like robustness

3

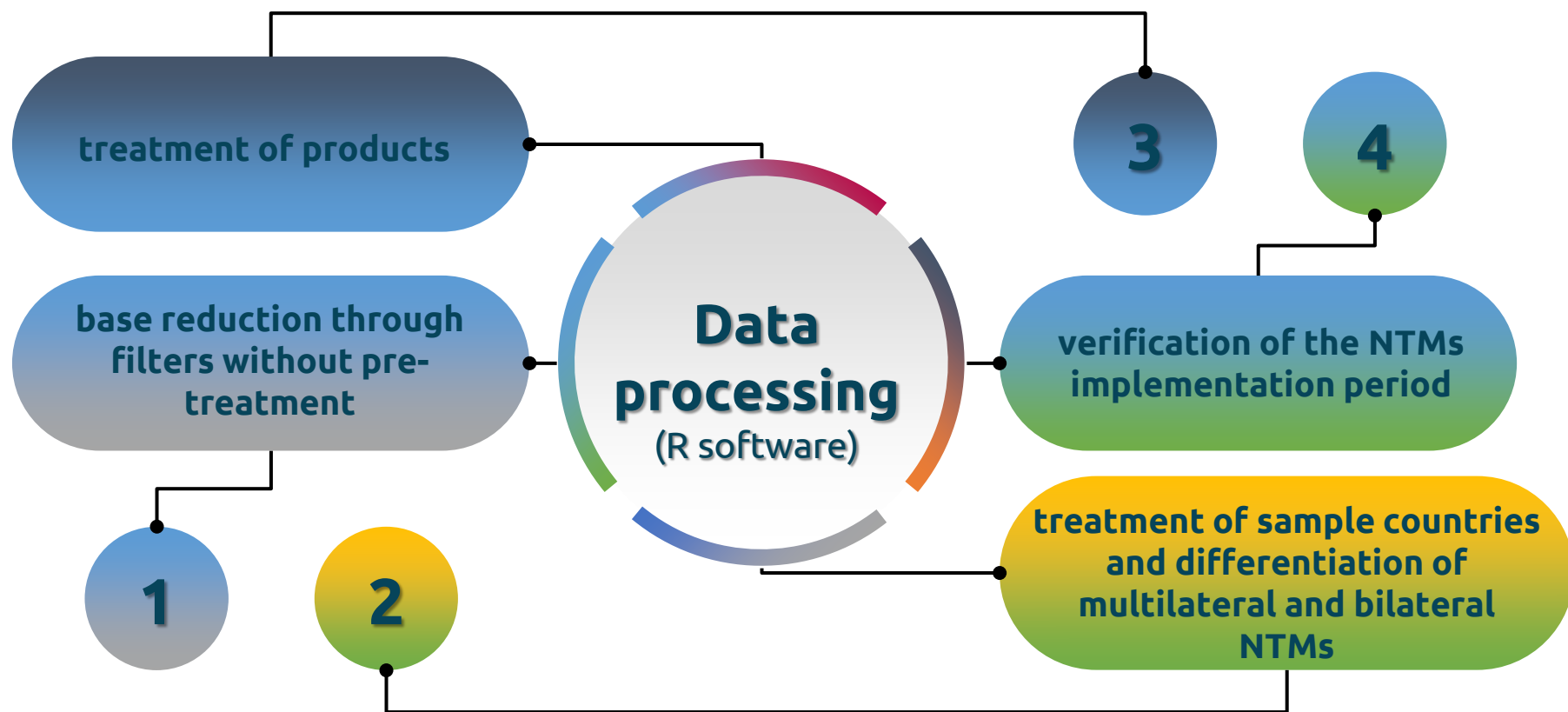
We included importer-year (γ_{it}), exporter-year (γ_{it}) country pair (η_{ij} (and sector (τ_k) fixed effects

4

Used the Poisson Pseudo Maximum Likelihood (PPML) method to estimate the gravity model. We PPML-HDFE



Several queries were carried out, **as data download was limited**, resulting in a total of **85,632 NTMs**.



1 - Base reduction through filters without pre-treatment

- i) a simple filtering was carried out based on the NTMs codes, keeping only those related to traceability;
- ii) a temporal filter was applied to keep only the NTMs implemented between 2012 and 2021
- iii) it was decided to consider the collection years 2019, 2020 and 2021 as a single year, removing duplicate NTMs.

2 - Treatment of sample countries and differentiation of multilateral and bilateral NTMs

- i) Select only countries imposed NTMs that represented, on average, 95% of global imports between 2012 and 2021, and the affected countries responsible for 95% of global exports;
 - a. European Union was split into its member countries;
 - b. groups of countries contained in a single cell were separated by row; and
 - c. "World, except (...)" was replaced by the exporters in the sample and the countries that were exceptions were removed;
- ii) multilateral NTMs codes were differentiated from bilateral ones by adding "_m" at the end of the NTM code.

3 - Treatment of products

- i) data cleaning process to remove unwanted characters without compromising the classification of products according to the HS;
- ii) We separated products by row; and
- ii) products were disaggregated to achieve the 6-digit classification.

4 - Verification of the NTMs implementation period

- i) for expiration dates after 2021, those containing the year 9999 and empty expiration dates, it was considered that the NTMs were valid until 2021, the limit year of the analysis
- ii) For the years between 2012 and 2020, the database expiration years were considered.

Figure 1. Countries imposing Traceability NTMs, Total number of NTMs.

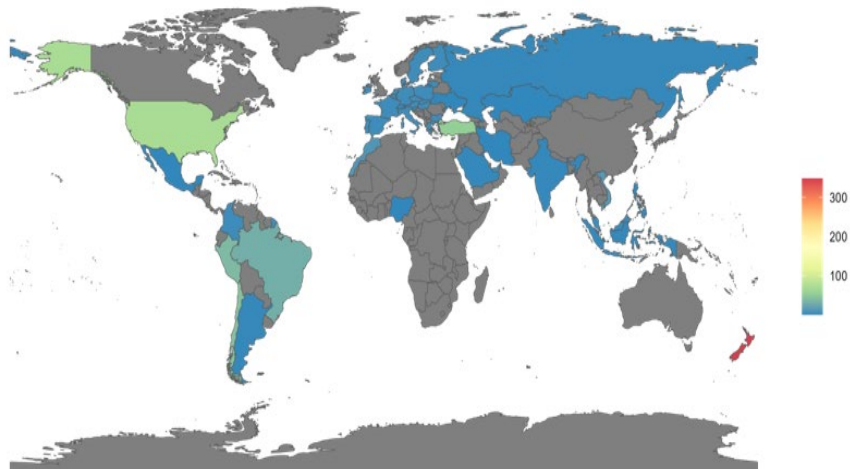
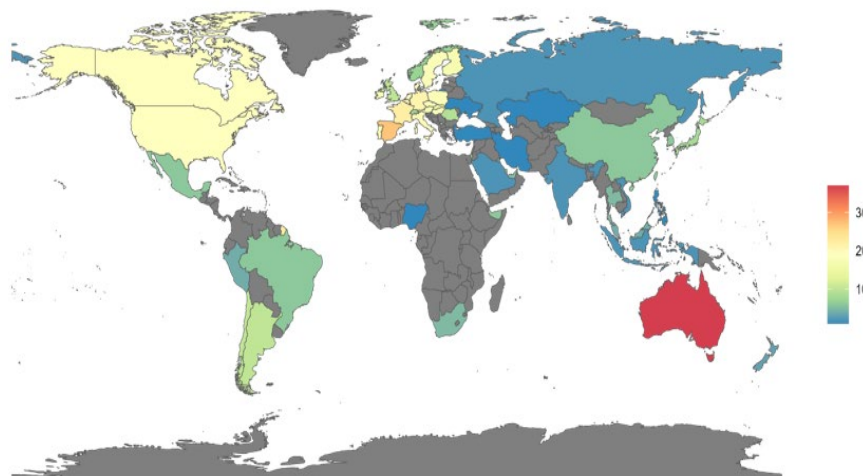
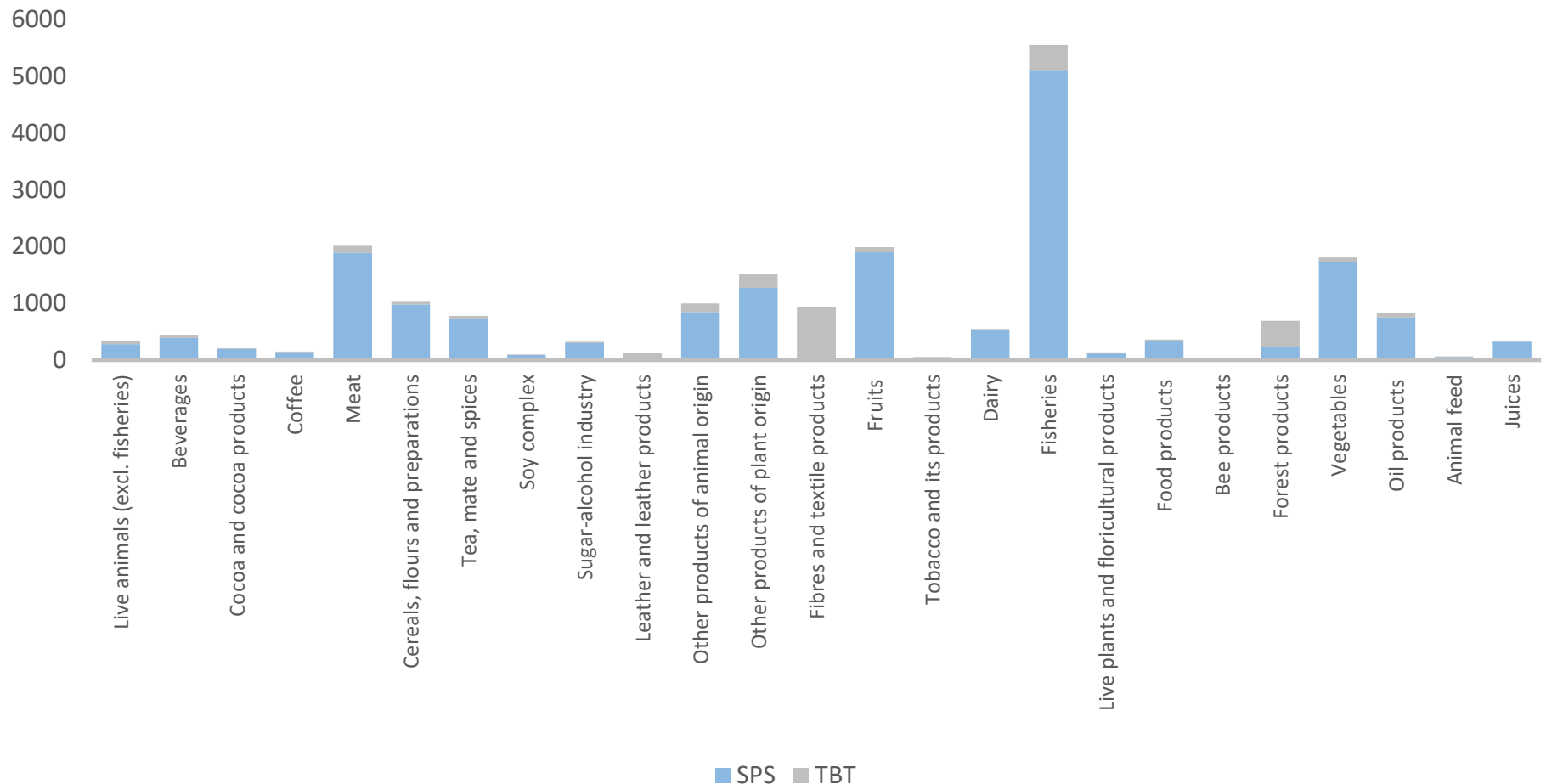


Figure 2. Affected countries of Traceability NTMs, Total number of measures



Source: Own elaboration. Research results.

Figure 3. Distribution of Traceability related SPS and TBT measures by sector (HS six-digit product disaggregation)



Source: Own elaboration. Research results.

Econometric results- summary of results

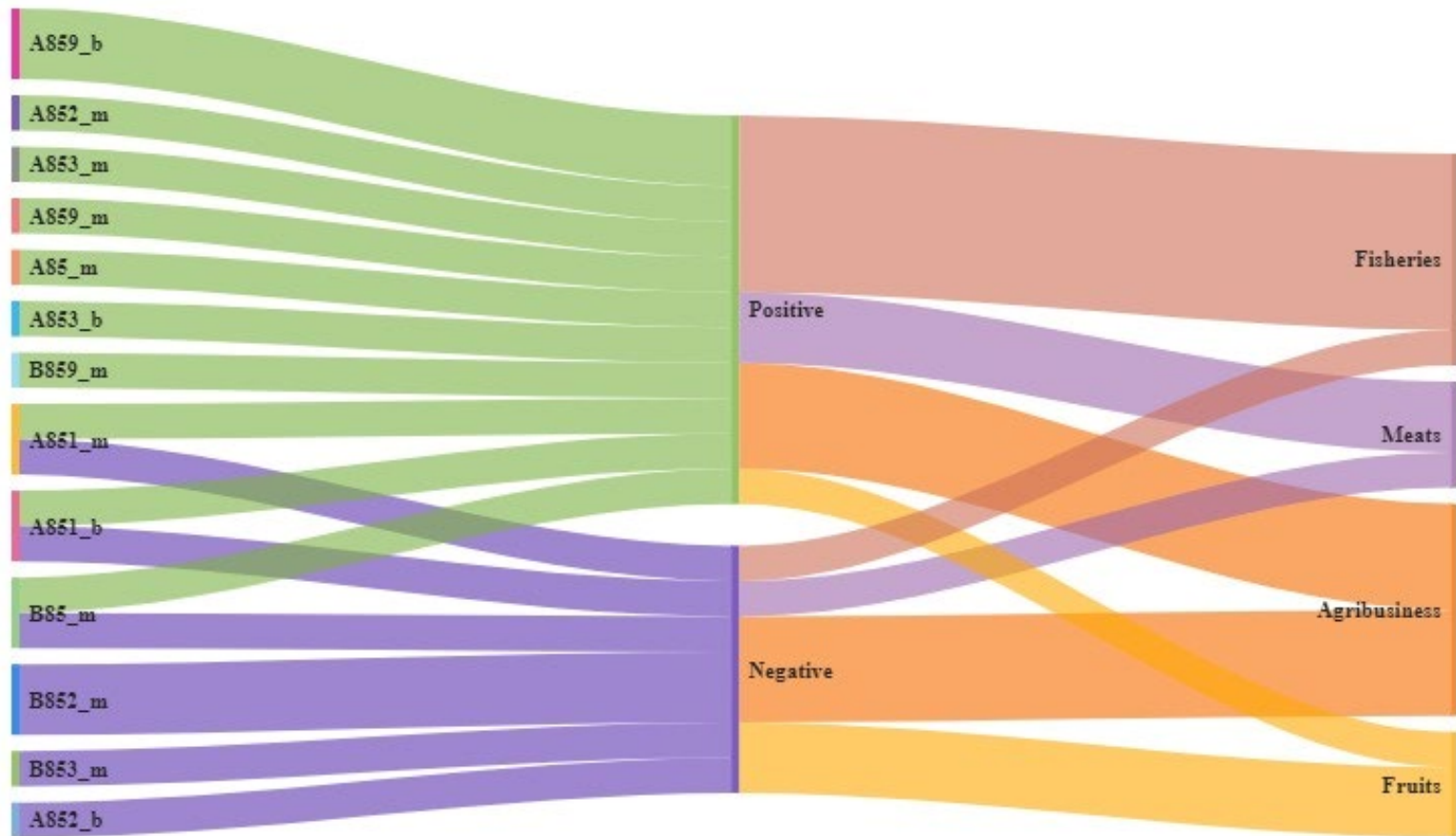
Table 8. Estimation results.

	All				Agribusiness – income levels			Meats – income levels			Fruits – income levels			Fisheries – income levels		
	Agribusiness	Meats	Fruits	Fisheries	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
fta_{ijt}	-0.182* (0.104)	-0.399*** (0.154)	0.064 (0.097)	-0.895** (0.392)	0.318** (0.151)	-0.378** (0.168)	-0.655*** (0.125)	0.987* (0.562)	-0.250 (0.468)	2.246*** (0.321)	0.268 (0.174)	1.259 (0.950)	0.652*** (0.149)	-0.484 (0.541)	-1.298** (0.522)	-1.580*** (0.206)
$A85_{bijkt}$	-0.249 (0.223)	0.024 (0.242)	-0.764 (0.485)	-	-1.252*** (0.238)	-	-0.315 (0.411)	-	-	-0.443* (0.227)	-	-	-0.285 (0.719)	-	-	-
$A851_{bijkt}$	0.292 (0.183)	0.450 (0.555)	-1.215*** (0.244)	0.968*** (0.232)	0.172 (0.333)	0.986*** (0.332)	0.133 (0.220)	1.289*** (0.205)	2.308*** (0.161)	-1.351 (0.904)	-	0.431 (0.532)	-1.461*** (0.214)	-	-	0.973*** (0.343)
$A852_{bijkt}$	-1.734*** (0.650)	-	0.304 (0.978)	-	1.548 (1.491)	0.347 (0.629)	-1.347 (0.843)	-	-	-	-	-	2.576*** (0.258)	-	-	-
$A853_{bijkt}$	-0.160 (0.275)	-	0.957** (0.456)	-	0.173 (0.298)	-0.063 (0.476)	-1.701*** (0.570)	-	-	-	-	-	-	-	-	-
$A859_{bijkt}$	1.522*** (0.417)	1.258*** (0.236)	-0.648 (0.991)	-	-1.433 (1.592)	-	0.914 (0.598)	1.769*** (0.438)	-	-	-	-	-2.815*** (0.281)	-	-	-
$B851_{bijkt}$	-0.468 (0.319)	-	-	-	-0.070 (0.414)	-0.545 (0.403)	-	-	-	-	-	-	-	-	-	-
$A85_{mikt}$	-0.008 (0.085)	-0.366 (0.402)	-0.225 (0.262)	0.795*** (0.248)	0.010 (0.158)	-0.307 (0.315)	-0.087 (0.083)	-	-	-0.543 (0.486)	-0.317 (0.514)	0.025 (0.713)	-0.239 (0.245)	1.992*** (0.411)	0.815 (0.517)	0.653** (0.305)
$A851_{mikt}$	0.105*** (0.040)	0.479 (0.449)	0.072 (0.290)	-0.552** (0.249)	0.325* (0.168)	0.205 (0.328)	0.029 (0.031)	-	-	0.600 (0.439)	-1.206* (0.685)	-0.728* (0.399)	0.114 (0.276)	-1.124 (0.911)	-2.225*** (0.829)	-0.108 (0.256)
$A852_{mikt}$	0.164 (0.209)	3.789*** (0.496)	-	-0.058 (0.298)	-0.680** (0.324)	-0.774* (0.467)	0.062 (0.239)	-	-	3.550*** (0.509)	-	-	-	-1.798*** (0.614)	-0.230 (0.592)	-0.224 (0.754)
$A853_{mikt}$	-0.181 (0.357)	-	-	1.129** (0.559)	-	-	0.165 (0.391)	-	-	-	-	-	-	-	-	0.738 (0.894)
$A859_{mikt}$	-0.006 (0.233)	-	0.342 (0.481)	1.575** (0.701)	-0.686** (0.350)	-0.576 (0.417)	0.434*** (0.115)	-	-	-	-	-	-0.250 (0.412)	2.336** (0.954)	0.850 (0.561)	-0.893 (1.053)
$B85_{mikt}$	0.813** (0.332)	-1.519*** (0.385)	0.309 (0.446)	-0.367 (0.412)	-0.458 (0.612)	-1.349** (0.596)	0.129 (0.348)	-	-	-1.681*** (0.413)	-0.053 (0.861)	1.142*** (0.325)	-	-0.762 (0.852)	-1.787** (0.897)	-1.403*** (0.452)
$B851_{mikt}$	0.018 (0.085)	-	-	-	-0.190 (0.175)	0.572** (0.246)	-0.011 (0.124)	-	-	-	-	-	-	-	-	-
$B852_{mikt}$	-0.778** (0.308)	-	-4.922*** (1.077)	-	-1.548*** (0.433)	0.153 (0.402)	-	-	-	-	-2.385** (1.105)	-8.116*** (1.197)	-	-	-	-
$B853_{mikt}$	-0.979*** (0.209)	-	-	-	0.398 (0.504)	1.399* (0.750)	-1.008*** (0.254)	-	-	-	-	-	-	-	-	-
$B859_{mikt}$	-0.016 (0.259)	0.708 (0.527)	-	0.571* (0.331)	-0.294 (0.208)	-0.020 (0.301)	0.500** (0.215)	-0.529 (0.637)	1.290 (0.784)	-	-	-	-	0.328 (0.331)	0.168 (0.618)	0.825* (0.425)
<i>Constante</i>	8.891*** (0.034)	9.680*** (0.157)	9.146*** (0.133)	8.465*** (0.106)	9.226*** (0.010)	9.882*** (0.023)	9.096*** (0.052)	10.621*** (0.005)	12.186*** (0.031)	9.652*** (0.242)	9.278*** (0.039)	9.582*** (0.144)	9.172*** (0.135)	8.236*** (0.072)	8.819*** (0.080)	8.641*** (0.166)
Observations	16,756,740	593,362	801,878	2,013,326	4,182,780	1,823,076	7,336,212	128,820	44,352	295,526	181,033	86,789	365,064	434,808	214,332	912,051
R ²	0.569	0.685	0.626	0.595	0.627	0.591	0.613	0.783	0.852	0.713	0.658	0.675	0.663	0.637	0.619	0.627
Fixed effects	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a	Yes ^a

Source: own elaboration. Research results. Model (1) considers exporters from developing countries (lower middle income and upper middle income) and importers from developed countries (high income); model (2) exporters and importers are developing countries (lower middle income and upper middle income); and model (3) exporters and importers are developed countries (high income). Note: Values in parentheses refer to robust standard errors clustered by country pair. * $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$. FE are for importer year, exporter year, product, and country pair. Missing values in the dependent variable have been replaced with zero, indicating that there is no bilateral trade for the pair combination of country, product, and year.

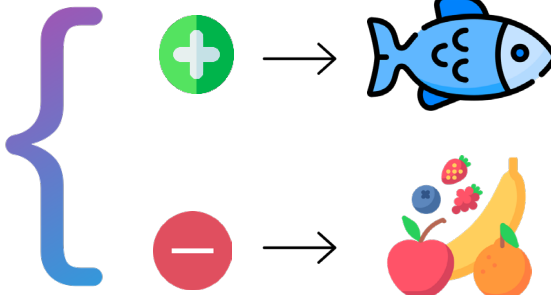
Econometric results- summary of results

Figure 5. Traceability NTMs effects on sectors. Analysis for all countries in the sample, without income level distinction





Source: own elaboration. Research results.

- According to Figure 5 it can be seen that the same measure has different effects depending on the sector - results for agribusiness can be very different when individual sectors are considered.
- It can be observed that the same NTM – i) **positive effects** for all sectors and countries involved ($A85_{m_{ikt}}$ and $B859_{m_{ikt}}$); ii) **negative effects** ($A85_{b_{ijkt}}$ and $B852_{m_{ikt}}$ measures); iii) **dubious effects** depending on the sector and income level of the countries involved.

- The NMT $A851_{b_{ijkt}}$ 

- Relating the cost effect to the results found for countries with different income levels, we find that trade in fruits and agribusiness products is primarily affected by NTMs in traceability.

- These heterogeneous effects are due to differences in compliance costs across countries:
 -  indicates that the exporter has complied with the NTM regulatory traceability requirements and expanded the supply of the regulated product;
 -  on the other hand, results from a decrease in the supply of the regulated product caused by the increased cost of implementing regulatory requirements
- In the analysis for all countries in the sample, there is no pattern in impact between bilateral and multilateral measures, but in the agricultural sector bilateral measures have a greater magnitude;
- In other sectors, the impact of multilateral measures is greater in absolute terms than that of bilateral measures, even when all countries are considered without distinguishing income levels.

- The results show that achieving traceability in the agri-food industry is a challenge that can have different implications depending on the sample studied.
- In the regulatory context, different outcomes may be related to the diversity of stages in the production process, which requires the involvement of different actors involved in the production chains.
- In addition, traditional food supply chains may face transparency and trust issues due to the (lack of) centralization of information.

- Traceability can contribute to promoting more **sustainable and safe practices in agri-food trade**, but its **impact on trade varies depending on the specific context**.
- Econometric results demonstrated that these measures can have **heterogeneous effects on the sectors and countries involved**.
- This result corroborates with the literature that **NTMs should be analyzed with moderation and the effects can not be generalized across sectors and countries with different levels of development**.
- Governments and public authorities need to find **balanced solutions** that **serve public interests, promoting efficiency and competitiveness on a global scale** and **providing sufficient logistical and technological infrastructure so that producers can adhere to traceability systems**.