



Standards and trade in forest-wood-paper sector

Bossoma Doriane N'Doua

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POUR OBTENIR LE GRADE DE
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*ECOLE DOCTORALE ENTREPRISE, ÉCONOMIE ET SOCIÉTÉ (ED 42) SPÉCIALITÉ SCIENCES
ÉCONOMIQUES*

Par

Bossoma Doriane N'Doua

Normes et Échanges Commerciaux dans la Filière Forêt-Bois-Papier

sous la direction de **Michel Dupuy**, Professeur des Universités

Soutenue le 24 Juin 2024

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*"Better is the end of a thing than its beginning, and the patient in spirit is better
than the proud in spirit." Ecclesiastes 7:8*

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Résumé

Cette thèse analyse les effets des réglementations, des normes et des certifications sur le commerce dans le secteur du bois. Elle contribue à la littérature empirique sur les effets des politiques commerciales sur le commerce international. Elle s'articule autour de quatre chapitres. Le premier chapitre examine les effets des mesures sanitaires et phytosanitaires (SPS) et des obstacles techniques au commerce (OTC), en distinguant les règlements techniques et les procédures d'évaluation de la conformité sur le commerce dans la filière forêt-bois-papier. Les résultats de ce chapitre montrent que la valeur du commerce augmente avec les procédures d'évaluation de la conformité SPS et OTC, et avec les règlements techniques OTC. Le commerce en provenance des pays en développement est négativement impacté par les procédures d'évaluation de la conformité imposées par les pays développés. Les effets varient également en fonction du sous-secteur considéré. Dans le deuxième chapitre, nous analysons les effets des mesures SPS dites restrictives, qui ont fait l'objet d'au moins une préoccupation commerciale spécifique, sur la valeur et la durée du commerce du bois et des articles en bois. Comme le suggère la littérature, nous constatons que le commerce est de courte durée. Les mesures SPS restrictives réduisent le commerce du bois et des articles en bois, mais n'ont pas d'impact significatif sur la durée des échanges. Le troisième chapitre se concentre sur l'impact de la mise en œuvre des réglementations sur le bois visant à promouvoir le commerce légal du bois sur les exportations de bois et de produits du bois en provenance de pays où la part de l'exploitation forestière illégale est élevée. Les résultats de ce chapitre mettent en évidence un impact négatif de la mise en œuvre de ces réglementations sur la valeur du commerce. Cet effet est particulièrement significatif pour l'industrie du papier et les meubles en bois, ainsi que pour les réglementations mises en œuvre par l'Union européenne, les États-Unis et l'Australie. Le dernier chapitre analyse les effets de la certifi-

cation de la gestion forestière sur les exportations des entreprises françaises. Nous trouvons que lorsque la part des forêts certifiées dans le pays exportateur (France) augmente par rapport à celle des pays importateurs ou de destination, les exportations augmentent. Cet effet est plus faible pour les grandes entreprises. Nos résultats mettent également en évidence des effets hétérogènes selon la catégorie de produits, la zone géographique et le niveau de revenu des pays de destination.

Mots Clés: Normes, Réglemenations, certifications, Commerce, Filière bois

Abstract

This thesis analyzes the effects of regulations, standards and certifications on trade in the wood sector. It contributes to the empirical literature on the effects of trade policies on international trade. It is structured around four chapters. The first chapter examines the effects of sanitary and phytosanitary measures (SPS) and Technical Barriers to Trade (TBT), distinguishing between technical regulations and conformity assessment procedures on trade in the forest-wood-paper sector. The results of this chapter show that the value of trade increases with SPS and TBT conformity assessment procedures, and with TBT technical regulations. Trade from developing countries is negatively impacted by conformity assessment procedures imposed by developed countries. The effects also vary according to the subsector under consideration. In the second chapter, we analyze the effects of so-called restrictive SPS measures, which have been the subject of at least one specific trade concern, on the value and duration of trade in wood and wood articles. As the literature suggests, we find that trade is short-lived. Restrictive SPS measures reduce trade in wood and wood articles, but have no significant impact on the duration of trade. The third chapter focuses on the impact of implementing timber regulations to promote legal timber trade on exports of timber and timber products from countries with high levels of illegal logging. The results of this chapter show that the implementation of these regulations has a negative impact on the value of trade. This effect is particularly significant for the paper industry and wooden furniture, as well as for regulations implemented by the European Union, the United States and Australia. The final chapter analyzes the effects of forest management certification on the exports of French firms. We find that when the share of certified forests in the exporting country (France) increases relative to that in importing or destination countries, exports increase. This effect is weaker for larger firms. Our results also highlight heterogeneous effects according to product

category, geographic area and income level of destination countries.

Keywords: Standards, Regulations, Certifications, Trade, Wood sector

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Introduction

Forests and related activities, such as wood production, play a key role in society and the economy. It is estimated that forests cover around 31% of the world's land surface, provide habitats for diverse species such as amphibians and mammals, over 86 million green jobs, and are the livelihood of a large proportion of the population (FAO, [2020](#)). In FAO ([2022](#)) report, the forestry sector's contribution to the global economy is estimated to have increased by 17% between 2011 and 2015, with a direct contribution to global GDP of 663 billion USD and over 1.52 trillion USD to national economies taking into account all economic effects in 2015. The forestry sector also contributes to providing jobs and income for a significant proportion of the population. It provides around 45 million jobs worldwide and generates over 580 billion USD in revenue each year. Forests also contribute to the fight against climate change thanks to their capacity to sequester and store carbon, a considerable asset for environmental protection (FAO, [2022](#)).

In addition to the economic and social benefits of forests, the main use of forests is production. In fact, around 30% of forests, or 1.15 billion hectares, are managed primarily for the production of wood and non-wood forest products. Wood and wood products are an integral part of society. They are used for a variety of purposes, including construction, furniture, packaging, heating, cooking and, in some cases, energy production, making them an important sector in their own right.

The wood sector is mainly based on wood production and processing, and includes products such as roundwood, logs, pulpwood, other industrial roundwoods, sawn timber, paper and cardboard (Brack, [2018](#)). Over the past decade, this sector has grown in importance due to the increasing demand for wood products. Brack ([2018](#)) points out that several factors

explain this increased demand for wood products, including population growth, changing income levels, technological development, including the development of wood processing technologies. This rise in demand is reflected in increased production and trade in wood and wood products. World production and trade in wood products, such as industrial roundwood, sawn lumber and wood-based panels, has reached a significant level since 1947 (FAO, [2019a](#)).

The fight against climate change is helping to increase demand for wood products. Climate change is one of the greatest threats to our society. Wood is a key sector. In addition to the storage and absorption capacity of forests, wood products are beneficial to the environment. Wood products represent a great opportunity to reduce greenhouse gas emissions and store carbon. Wood and wood products can be used to replace products that emit large quantities of greenhouse gases and fossil fuels, because of their recyclable nature and low greenhouse gas emissions. Construction, furniture and communications use wood as one of the main primary materials. A biodegradable and renewable resource, wood is an effective carbon store as long as products remain intact inside buildings or other structures (Reid et al., [2004](#)).

As some countries are better off than others in terms of forest area, international trade appears to be the key element through which countries can benefit from and exploit this resource. Trade is increasingly governed by trade policies, standards and certifications with multiple objectives. These trade measures are therefore a determining factor in market penetration and share. Given the strategic and essential role of this sector, its international reach through trade, and the potential impact of policy measures on market. Considering the specificities of the wood sector, this thesis aims to shed light on the effects of trade policies on international trade in the wood sector.

According to FAO statistics, the highest values for global production and trade in the main wood products were achieved in 2018, with growth in wood-based product production ranging from 1% (wood-based panels) to 5% (industrial roundwood), fastest in the Asia-Pacific, North America and Europe regions (FAO, [2019a](#)). However, not all products are on the same footing: the paper industry has seen its global production decline, notably by 1.5% for paper and cardboard. Growth in global wood products production and trade is partly due to China, which has really taken off in recent years, gaining in importance not only as a producer and consumer of forest products, but also as the world's leading importer of industrial

roundwood, sawnwood and furniture fiber (pulp and recycled paper), and leading exporter of wood-based panels (FAO, 2019a). Table 1 presents world production and trade in 2020, focusing on trends relative to 1980, 2000 and 2019. Overall, all the products considered have seen significant growth in production and trade since 1980.

Table 1: Global production and trade in forest products in 2020

Product	Unit	Production				Exports			
		Change (%) compared to				Change (%) compared to			
		2020	2019	2000	1980	2020	2019	2000	1980
Roundwood	million m3	3912	-1%	12%	25%	140	-2%	19%	50%
Wood fuel	million m3	1928	-1%	7%	15%	6	-15%	79%	
Industrial roundwood	million m3	1924	-2%	17%	37%	134	-1%	17%	43%
Wood pellets and other agglom- erates	million tonnes	50	3%			31	6%		
Sawnwood	million m3	473	-3%	23%	12%	153	-3%	34%	118%
Wood-based panels	million m3	367	-1%	107%	280%	88	-2%	67%	490%
Plywood	million m3	118	2%	103%	200%	28	-6%	60%	326%
Particle board, OSB and fibre- board	million m3	250	-2%	109%	335%	60	0%	71%	622%
Wood pulp	million tonnes	186	-2%	9%	48%	69	1%	80%	226%
Pulp from fibres other than wood	million tonnes	11	-1%	-26%	55%	0.4	7%	15%	79%
Recovered paper	million tonnes	229	-1%	59%	352%	45	-8%	83%	716%
Paper and paperboard	million tonnes	401	-1%	24%	137%	111	-2%	13%	218%
Forest products value	US\$ billion					244	-10%	68%	331%

Source: FAO, 2021 Forest product statistics. <https://www.fao.org/forestry/statistics/80938/en/>

In terms of quantities produced, wood-based panels, recycled paper and cardboard are the products that have seen the largest increase since 1980. Exports of wood-based panels, pulp, recycled paper, paper and cardboard have seen the biggest increase. This increase in production and exports continued in comparison with 2000 for all products, with the exception of non-wood fiber pulp, where the quantity produced declined. Compared with 2019, exports of all products decreased, with the exception of wood pulp and non-wood fiber pulp exports, which increased by 1% and 7% respectively and wood pellets and other agglomerates production quantities which increase by 3%.

Table 2 presents the main producers and consumers of forest products. Forest products production is geographically varied, but largely dominated by the United States of America (USA), China, Brazil and India, which produce the majority of the world's wood products. However, the USA and China are major producers of forest products, notably wood-based panels and paper. China has gained in importance and is now well ahead of the USA in the production of wood-based panels, recycled paper, paper and cardboard. In terms of forest product consumption, the same players - the USA, China, Brazil and India - dominate the majority of products. The USA and China are the main consumers of sawn timber, wood-based panels and paper, with China predominating.

Table 2: Forest product consumption and production: Major consumers of forest products

	Major producers of forest products (Percentage of global production (2020))	Major consumers of forest products (Percentage of global consumption (2020))
Wood Fuel	India (16%); China (8%); Brazil (6%); Ethiopia (6%); Democratic Republic of Congo (5%); Nigeria (3%); United States of America (3%).	India (16%); China (8%); Brazil (6%); Ethiopia (6%); Democratic Republic of Congo (5%); Nigeria (3%); United States of America (3%).
Industrial roundwood	United States of America (19%); Russian Federation (10%); China (9%); Brazil (7%); Canada (7%); Indonesia (4%); Sweden (4%); Germany (3%); Finland (3%).	United States of America (18%); China (12%); Russian Federation (9%); Brazil (7%); Canada (6%); Indonesia (4%); Sweden (4%); Finland (3%); Germany (3%); India (3%).
Wood charcoal	Brazil (12%); Nigeria (9%); Ethiopia (9%); Democratic Republic of Congo (5%).	Brazil (12%); Ethiopia (9%); Nigeria (9%); India (5%); Democratic Republic of Congo (5%).
Wood pellets and other agglomerates	United States of America (17%); Canada (8%); Germany (8%); Russian Federation (7%); Viet Nam (7%); Brazil (6%); Latvia (5%); Sweden (4%); France (3%); Poland (3%); Estonia (3%); Austria (3%).	Brazil (12%); Ethiopia (9%); Nigeria (9%); India (5%); Democratic Republic of Congo (5%).
Sawnwood	China (18%); United States of America (17%); Russian Federation (9%); Canada (8%); Germany (6%); Sweden (4%).	China (25%); United States of America (22%); Germany (5%); Canada (3%); Japan (3%).
Wood-based panels	China (44%); United States of America (9%); Russian Federation (4%); Germany (3%); India (3%); Canada (3%); Brazil (3%); Poland (3%).	China (41%); United States of America (13%); India (3%); Germany (3%); Russian Federation (3%); Poland (3%).
Pulp for paper	United States of America (26%); Brazil (11%); China (9%); Canada (8%); Sweden (6%); Finland (5%); Russian Federation (4%); Indonesia (4%); Japan (4%); India (3%); Chile (3%).	United States of America (26%); China (23%); Japan (4%); Sweden (4%); India (4%); Russian Federation (4%); Canada (3%); Finland (3%); Brazil (3%); Germany (3%).
Recovered paper	China (24%); United States of America (18%); Japan (8%); Germany (7%); Republic of Korea (4%); United Kingdom (3%); France (3%).	China (27%); United States of America (12%); Germany (8%); Japan (7%); India (4%); Republic of Korea (4%); Mexico (3%); Indonesia (3%).
Paper and paperboard	China (28%); United States of America (17%); Japan (6%); Germany (5%); India (4%); Republic of Korea (3%); Indonesia (3%); Brazil (3%).	China (30%); United States of America (16%); Japan (5%); Germany (5%); India (5%); Republic of Korea (3%); Italy (3%).

Source: FAO, 2021 Forest product statistics. <https://www.fao.org/forestry/statistics/80938@180723/en/>

Figure 1: Values of world trade in goods by sectors.

Source: UNCTAD (2023a)

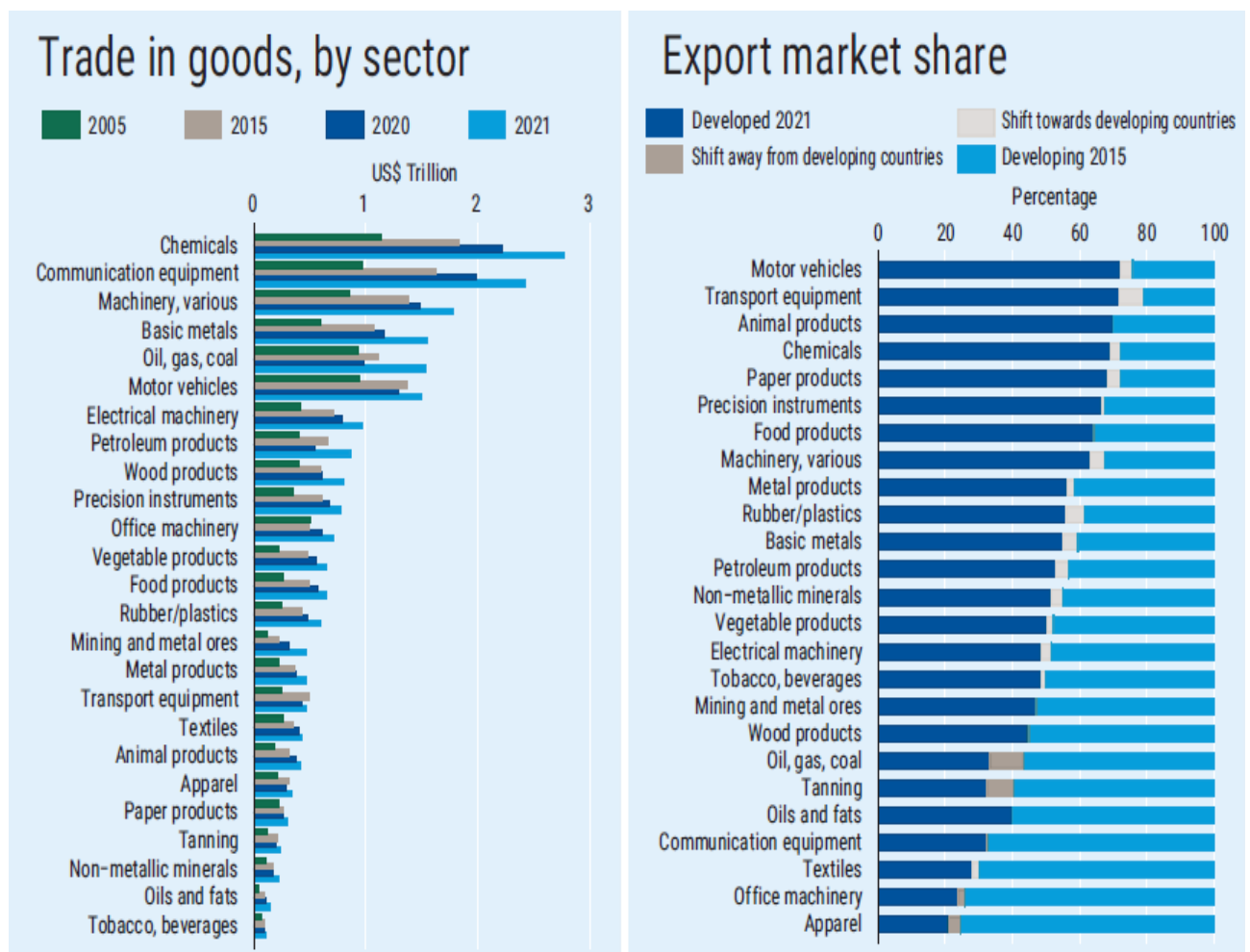


Figure 1 shows the value of trade in goods by sector and export market share. The value of trade has increased in most sectors, with the most significant increase in chemicals and communication equipment sector. For wood products, the value of trade increased significantly compared to 2005. In contrast, the value of trade for paper products has risen steadily over time. Since 2015, export market shares have benefited developing countries for paper products, and remain similar between developed and developing countries for wood products. The wood sector occupies an important position on the international market, stimulated by the expansion of several economies, notably China.

Table 3 presents the main exporters and importers of forest products, and provides an overview of the main players in the international trade of these products. The international forest products market is diversified. In terms of exports, no single country stands out for all forest products. In the case of wood, European and oceanic countries hold a key position,

such as New Zealand and the Czech Republic for industrial wood, and Russia, Vietnam, the USA, China and Brazil for processed products, respectively sawnwood, veneer sheets, wood-based panels and pulp. For paper and paperboard, Germany leads the way, ahead of the USA. In terms of imports, China is the main importer of most forest products, particularly for the paper industry, the USA dominates for wood-based panels and the United Kingdom (UK) for wood pellets and other agglomerates. For wood fuel, South Africa is the main importer, although Eswatini occupies a central position as both importer and exporter.

These tables and figures provide an overview of the diversified forest products market and the expansion of forest products production and trade in recent decades.

Table 3: Forest products trade: Major exporters of forest products

	Major exporters of forest products (Percentage of global exports (2020))	Major importers of forest products (Percentage of global imports (2020))
Wood Fuel	Eswatini (9%); Bosnia and Herzegovina (9%); France (9%); Croatia (8%); Latvia (8%); Spain (7%); Netherlands (5%); Lithuania (5%); South Africa (5%).	South Africa (15%); Italy (15%); Eswatini (7%); United Kingdom (6%); Germany (6%); France (5%); Austria (5%); Finland (4%).
Industrial roundwood	New Zealand (16%); Czechia (14%); Russian Federation (12%); Germany (9%); United States of America (5%); Canada (4%); Australia (4%); Poland (3%); Norway (3%).	China (44%); Austria (9%); Sweden (5%); Finland (5%); Germany (4%); Belgium (4%); Canada (3%); Republic of Korea (3%).
Wood charcoal	Indonesia (16%); Myanmar (9%); Namibia (7%); Poland (6%); Ukraine (5%); Mexico (4%); Nigeria (4%); Viet Nam (4%); India (4%); Cuba (4%); Paraguay (3%); Philippines (3%); Belgium (3%).	China (10%); Germany (6%); United States of America (6%); Poland (5%); Japan (5%); Saudi Arabia (4%); France (4%); Republic of Korea (4%); South Africa (4%); United Kingdom (4%).
Wood pellets and other agglomerates	United States of America (23%); Viet Nam (11%); Canada (10%); Russian Federation (8%); Latvia (8%); Denmark (3%); Estonia (3%); Austria (3%); Germany (3%).	United Kingdom (33%); Republic of Korea (13%); Denmark (12%); Netherlands (8%); Japan (7%); Italy (7%); Belgium (5%).
Sawnwood	Russian Federation (21%); Canada (17%); Sweden (9%); Germany (7%); Finland (5%); Austria (4%); United States of America (4%); Belarus (3%).	China (23%); United States of America (18%); United Kingdom (5%); Germany (4%); Japan (3%); Egypt (3%); Italy (3%); Belgium (3%).
Veneer sheets	Viet Nam (19%); Russian Federation (12%); Canada (11%); China (9%); Gabon (5%); United States of America (4%); Brazil (4%); Ukraine (3%); Thailand (3%).	China (24%); United States of America (12%); India (5%).
Wood-based panels	China (14%); Canada (8%); Russian Federation (7%); Germany (7%); Thailand (7%); Brazil (4%); Belarus (4%); Poland (4%); Indonesia (4%); Austria (3%); France (3%); Romania (3%); Belgium (3%); Turkey (3%).	United States of America (17%); Germany (7%); United Kingdom (4%); Japan (3%); Republic of Korea (3%); Canada (3%); Italy (3%); Poland (3%); Belgium (3%).
Pulp for paper	Brazil (25%); Canada (14%); United States of America (11%); Indonesia (8%); Chile (7%); Finland (6%); Sweden (6%); Uruguay (4%); Russian Federation (4%).	China (40%); United States of America (9%); Germany (6%); Italy (5%); Republic of Korea (3%); Netherlands (3%); France (3%).
Recovered paper	United States of America (32%); United Kingdom (9%); Japan (7%); France (5%); Netherlands (5%); Germany (5%); Italy (4%); Canada (3%); Belgium (3%).	China (15%); India (13%); Germany (10%); Viet Nam (8%); Indonesia (7%); Netherlands (5%); Mexico (4%); Thailand (4%).
Paper and paperboard	Germany (12%); United States of America (9%); Sweden (8%); Finland (7%); Canada (5%); Indonesia (5%); China (4%); Austria (3%); Russian Federation (3%); Belgium (3%); France (3%); Italy (3%).	China (11%); Germany (9%); United States of America (7%); Italy (4%); United Kingdom (4%); Poland (4%); France (4%); Belgium (4%); Mexico (3%).

Source: FAO, 2021 Forest product statistics. <https://www.fao.org/forestry/statistics/80938@180724/en/>

In the era of globalization, this expansion of trade in goods has been accompanied by the emergence of non-tariff measures. Globalization has reduced transport costs, lowered tariff barriers to trade and, above all, brought economies closer together, leading to cooperation between countries and the emergence of multilateral and regional trade agreements.

The General Agreement on Tariffs and Trade (GATT), with its negotiations and later the World Trade Organization (WTO), contributed significantly to the lowering of tariffs. The Uruguay Round agreement of 1994, in particular, had a major impact on lowering tariffs on forest products. Major importers in developed countries have committed to reducing tariffs on solid wood products by 50%, on a trade-weighted average basis, over a five-year period starting in 1995. They also agreed to eliminate tariffs on furniture over the next eight to ten years (Barbier, 1996). As Barbier (1996) points out, one of the main contributions of the Uruguay Round was the reduction in tariff escalation, which was cut by 30% for wood-based panels, 50% for semi-finished products and 67% for wood products.

Table 4 shows the percentage level of tariffs before and after the Uruguay Round and the reduction. Tariffs were considerably reduced in many sectors after the Uruguay Round. For forest products, there was a significant reduction of around 70% from all sources and all developing countries. Figure 2 shows average tariff levels by sector in 2010 and 2021. Compared to 2010, the percentage level of tariffs in many sectors has risen steadily for most of them. Retaliatory tariffs between the USA and China explain this increase in many sectors (UNCTAD, 2023b). In 2021, for paper and wood products, the average tariff level is around 2% and 3% respectively, which remains low compared to agricultural products.

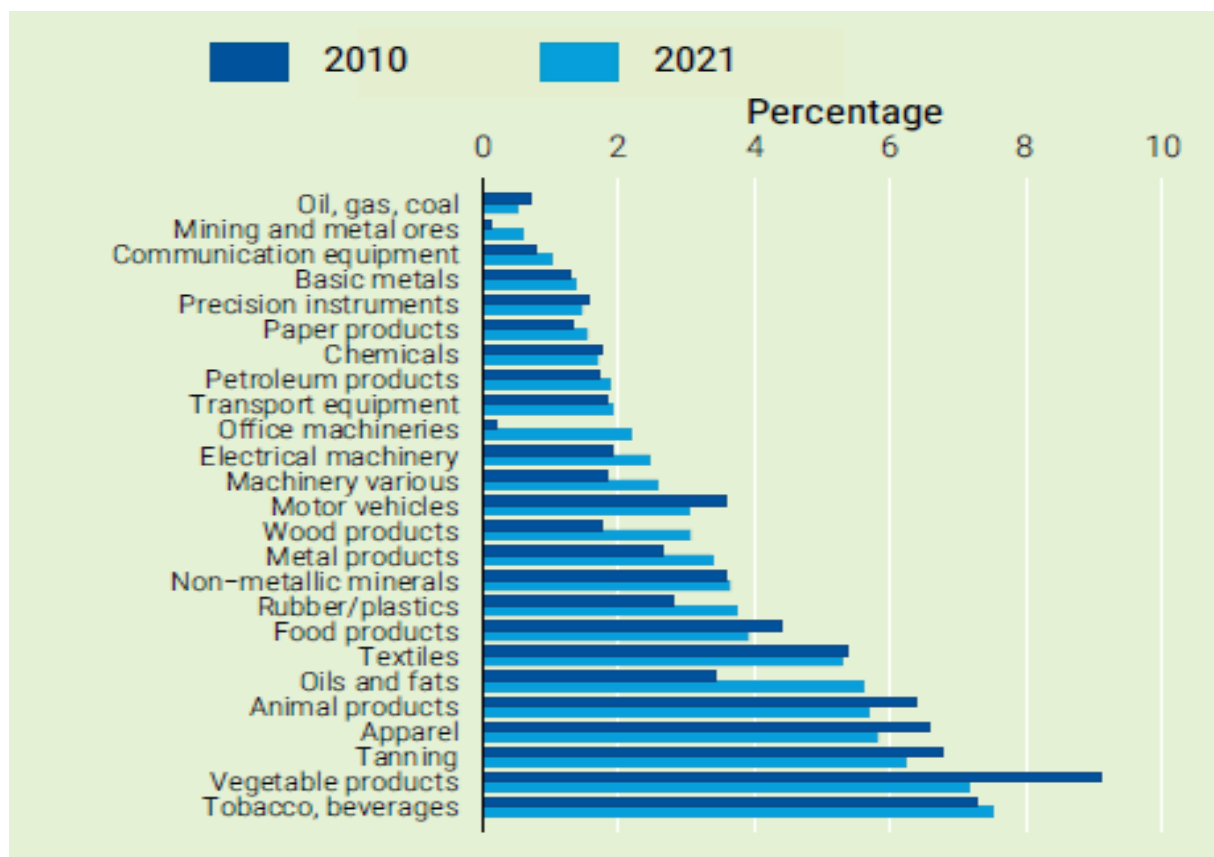
Table 4: Uruguay Round tariff reductions in developed countries by major industrial product group

	Imports from all sources				Import form developing countries				
Product Category	Import value (US\$ billion)	Tariff pre- UR (%)	Tariff post- UR (%)	Reduction (%)	Import value (US\$ billion)	Tariff pre-UR (%)	Tariff post- UR (%)	Reduction (%)	
Fish and fish products	18.5	6.1	4.5	26	10.6	6.6	4.8	27	
Forest products	40.6	3.5	1.1	69	11.5	4.6	1.7	63	
Textiles and clothing	66.4	15.5	12.1	22	33.2	14.6	11.3	23	
Leather, rubber, footwear and travel goods	31.7	8.9	7.3	18	12.2	8.1	6.6	19	
Metals	69.4	3.7	1.4	62	24.4	2.7	0.9	67	
Chemicals and photo- graphic supplies	61	6.7	3.7	45	8.2	7.2	3.8	47	
Transport equipment	96.3	7.5	5.8	23	7.6	3.8	3.1	18	
Non-electrical machinery	118.1	4.8	1.9	60	9.8	4.7	1.6	66	
Electrical machinery	86	6.6	3.5	47	19.2	6.3	3.3	48	
Mineral products and pre- cious stones/metals	72.9	2.3	1.1	52	22.2	2.6	0.8	69	
Manufactured articles NES	76.1	5.5	2.4	56	10.9	6.5	3.1	52	
Industrial tropical products	32.8	4.2	2	52	14.4	4.2	1.9	55	
Natural resource products	80.2	3.2	2.1	34	33.4	4	2.7	33	
All industrial products	736.9	6.3	3.8	40	169.7	6.8	4.3	37	

Note: UR = Uruguay Round; NES = not elsewhere specified. Tariffs are based on weighted averages on imports from all sources, excluding petroleum products. Import data from 1990 or latest available year, and for all developed country participants in the Uruguay Round, excluding imports from free trade area partners (e.g. intra-European Union trade) and from contractual preferential arrangements. Forest products include Wood, pulp, paper and furniture. Source: Barbier (1996)

Figure 2: Trade weighted average tariffs, by sector.

Source: UNCTAD (2023b)



The reduction in tariffs has been accompanied by the emergence of non-tariff measures (NTMs). Non-tariff measures are defined as "policy measures other than ordinary tariffs that can potentially have an economic effect on international trade in goods, by altering traded quantities, prices or both." (UNCTAD, 2019). These measures are based on consumer protection and safety and the correction of market failures. They are distinguished by their diversity, characteristics and functions. They include measures to protect the environment, plants and consumer health, as well as measures to provide rules on product characteristics and the production process, or to set requirements for trade. The United Nations Conference on Trade and Development (UNCTAD) and experts from international organizations such as the World Bank, the Food and Agriculture Organization of the United Nations (FAO), the WTO and many others have established a classification of non-tariff measures with the aim of providing exporters with transparent information on these measures and thus pro-

moting trade. This classification is presented in 16 chapters according to field of application and/or objective. Each chapter is subdivided into subgroups, which are in turn subdivided by one, two or three digits. The number 9 is assigned to cases not included in the subdivisions (UNCTAD, 2019). These measures include technical and non-technical measures, grouped into 16 chapters from A to P. Chapters A to O concern imports, while chapter P concerns exports. Technical measures are those designed to protect health, the environment, plants and safety, and to improve product quality. They are related to production and product characteristics. According to the UNCTAD (2019), these technical measures are grouped under chapters A: Sanitary and phytosanitary measures (SPSs), B: Technical barriers to trade (TBTs) and C: Pre-shipment inspection and other formalities. The main measures are sanitary and phytosanitary measures and technical barriers to trade . Non-technical measures cover the conditions under which goods are traded.

SPS and TBT technical measures are similar to technical regulations, standards and conformity assessment procedures. However, a distinction needs to be made between these elements: standards are voluntary in nature and differ from technical regulations, which are mandatory. However, standards can be made mandatory by regulation. Conformity assessment procedures, are a means of proving compliance with a regulation, standard. This is a process by which a third party ensures that the characteristics of a product conform to a regulation, standard.

Standards, technical regulations and certifications are becoming increasingly important and indispensable to trade. They are based on the principles and agreements established by the WTO, notably the TBT agreement and the SPS agreement . The TBT agreement came into force on January 1, 1995 (WTO, 1994a). This agreement provides for the establishment of standards, technical regulations and conformity assessment procedures (certification, testing methods). The TBT agreement consolidated the "standardization code" provisions of the previous plurilateral agreement of the 1979 Tokyo Round on technical barriers to trade (WTO, 2014). This agreement was drawn up to prevent all forms of unnecessary obstacles to international trade, and to promote legitimate interests by granting governments a degree of flexibility in the design of regulatory systems. Unnecessary barriers are measures that create more problems than they solve, generate unnecessary constraints on trade, and fail to meet one or more legitimate objectives. Members must justify the measures they establish by means of a risk assessment, taking into account scientific data, processing techniques or

the end uses of the products.

In summary, the TBT Agreement allows members a certain level of autonomy in setting technical regulations and conformity assessment procedures, provided they comply with the provisions of the Agreement, to avoid pointless obstacles and promote the achievement of legitimate objectives.

The SPS agreement differs from the TBT agreement in its scope (WTO, 1994b). The SPS agreement defines "the fundamental rules concerning the safety of food products as well as the sanitary requirements for animals and plants" (WTO, 2010). This agreement aims to protect consumers, preserve plants and guarantee food safety. WTO (2010) specifies that these sanitary measures are applied by countries and can take various forms: product control, products authorized to enter the territory only from disease-free zones, product treatment and processing, definition of maximum acceptable levels of pesticides or obligation to use only certain food additives. In addition, as in the TBT agreement, the provisions of this agreement provide for transparency, in the form of notifications to the WTO Secretariat, the creation of enquiry points, publication requirements and the existence of an SPS committee responsible for providing information on the operation and implementation of this agreement.

The WTO TBT and SPS Agreements encourage members to rely on international standards to develop technical regulations, standards and conformity assessment procedures. WTO (2014) points out, on the one hand, international standards enable comparisons between countries by providing information on the production process and on the product to consumers. On the other, they facilitate international trade thanks to economies of scale and efficiency gains.

Since the creation of the WTO in 1995, SPS and TBT measures have increased and continue to regulate trade in wood and wood products.

Figure 3 shows the predominance of SPS and TBT measures by sector. SPS and TBT measures play an important role in international trade, covering a significant share of world trade in the majority of sectors. SPS measures regulate agriculture-related sectors, but are still present in wood and paper products, with a frequency index and coverage rate of over 15%. TBT measures are more widespread and regulate numerous sectors. They cover a large proportion (around 60%) of world trade in wood and paper products.

Figure 3: Non-tariff measures, by sector (2021).

Source: UNCTAD (2023b)

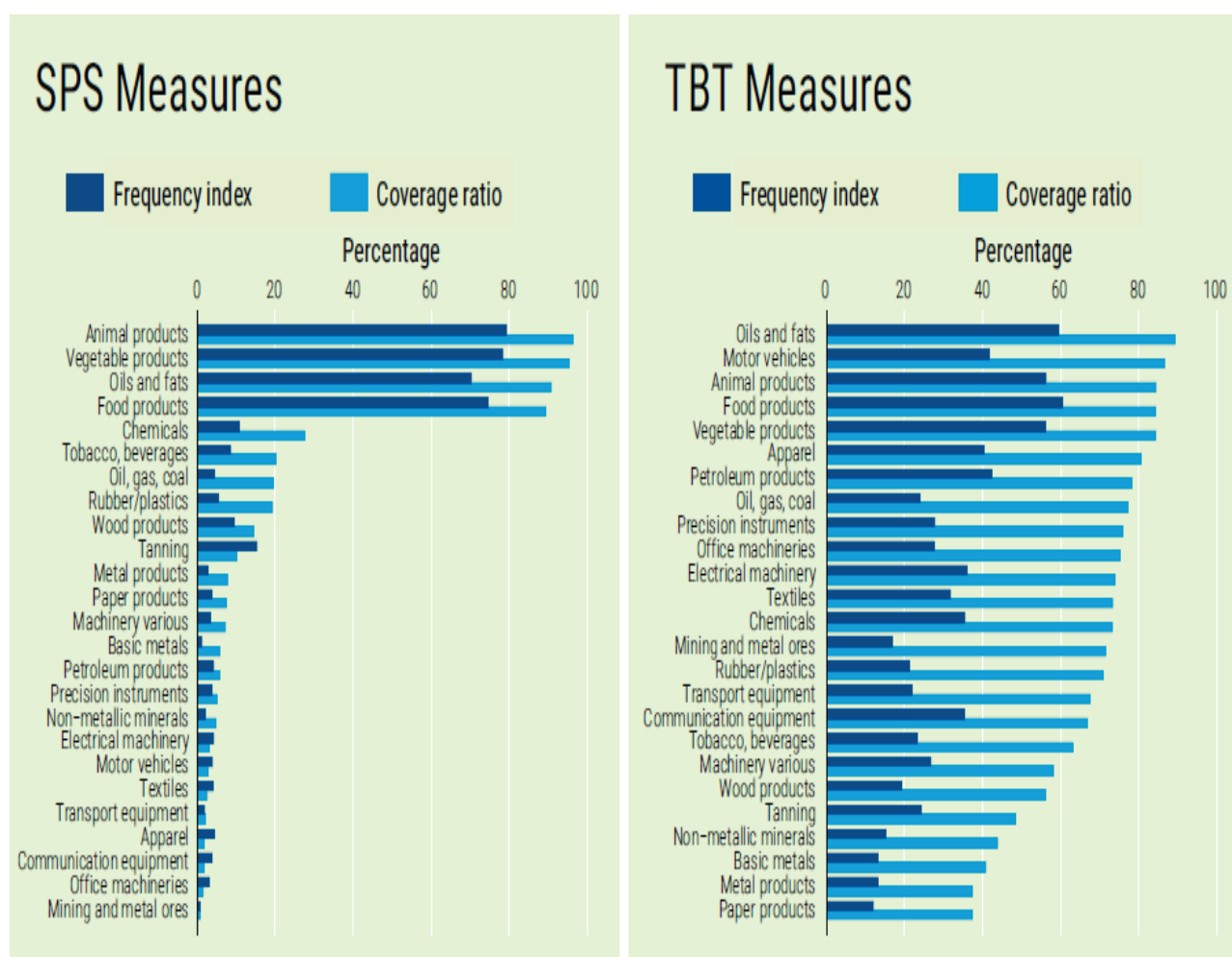


Figure 4 shows Ad Valorem Equivalents (AVEs) of Non-Tariff Measures estimates on unit value by sector. AVEs of a NTM is considered to be the proportional increase in the domestic price of the goods to which it applies, compared with a counterfactual in which it does not apply. For wood and paper products, AVEs are higher for TBT measures than for SPS measures. As Cadot et al. (2018) point out, high AVEs imply changes in product quality and design, suggesting that the unregulated market equilibrium may be far from the social optimum, or that policy is interfering with the efficient functioning of markets.

Figure 4: Baseline AVE estimates on unit value, by HS section.

Source: Cadot et al. (2018)

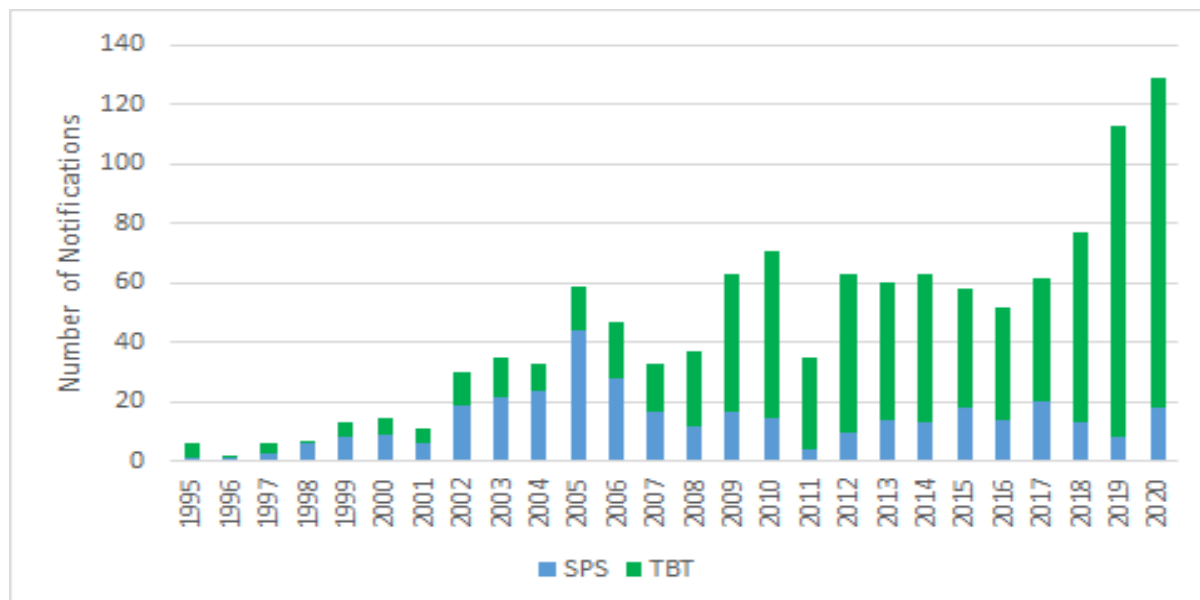
HS Section	Frequency weighted AVE					Unweighted AVE			
	SPS	TBT	BCM	QRs		SPS	TBT	BCM	QRs
Live animals	3.0%	14.8%	1.5%	0.9%	20.3%	4.6%	16.5%	2.8%	4.4%
Vegetable products	4.1%	10.0%	1.5%	0.3%	15.8%	5.5%	17.1%	6.9%	3.0%
Fats and Oil	10.8%	7.1%	0.8%	1.4%	20.0%	17.7%	9.1%	4.6%	4.6%
Processed food	14.8%	12.0%	0.3%	1.6%	28.7%	13.5%	12.1%	1.3%	6.6%
Chemical products	1.6%	5.8%	0.3%	0.7%	8.5%	5.8%	9.3%	1.9%	5.6%
Rubber Plastics	3.6%	4.5%	1.2%	0.6%	9.9%	10.5%	6.8%	13.0%	11.5%
Raw hide skins	0.1%	7.7%	0.7%	1.9%	10.4%	0.4%	6.0%	5.0%	14.4%
Wood	7.9%	13.9%	0.3%	4.7%	26.8%	25.0%	30.2%	0.5%	10.3%
Paper	2.1%	4.0%	0.1%	1.5%	7.7%	8.6%	10.4%	0.2%	4.8%
Textile	0.6%	10.8%	0.6%	0.9%	12.9%	11.4%	15.1%	3.3%	5.4%
Footwear	0.2%	0.9%	1.2%	6.0%	8.3%	5.1%	1.5%	4.4%	24.0%
Stone Cement	1.1%	6.8%	0.1%	0.4%	8.4%	11.2%	12.2%	0.7%	10.9%
Precious stones	0.4%	5.5%	0.9%	2.7%	9.5%	15.9%	16.1%	7.2%	18.9%
Base Metals	0.0%	4.4%	0.6%	1.3%	6.4%		9.1%	3.0%	13.4%
Machinery & Electrical Equipment	0.0%	4.8%	0.4%	0.9%	6.1%		10.1%	1.4%	7.9%
Motor Vehicles	0.0%	15.9%	0.7%	5.7%	22.3%		20.4%	1.5%	23.4%
Optical Medicals	0.0%	5.1%	1.1%	1.5%	7.7%		8.6%	4.2%	13.5%
Miscellaneous	0.0%	7.5%	0.0%	1.0%	8.6%		8.9%	2.1%	6.3%

Note: SPS is Sanitary and Phytosaitary measures, TBT is Technical barriers (standards),
BCM is Border control measures and QRs is Quantitative restrictions.

Figure 5 shows the number of notifications made by WTO member countries of SPS and TBT measures on wood and wood products. These notifications cover the period 1995-2020.

Figure 5: Number of SPS and TBT notifications per year in the wood sector.

Source: Author's based on data from SPS & TBT platform.



The number of notifications of SPS and TBT measures has been increasing since 1995, with a more significant rise in the 2000s, reflecting the importance of these measures on trade in wood and wood products. Notifications are compulsory and must be sent to the WTO secretariat 60 days before adoption (or later in the case of exceptions or identified problems). The purpose of these notifications is to provide information on the proposed regulations, their implications for trade, and to give members the opportunity to comment and express their concerns bilaterally, with the SPS and TBT committees or public authorities, and to adapt to these regulations. The member notifying these measures must take these comments and concerns into account and respond to them.

The SPS and TBT committees play an important role in informing members about the functioning of the agreement and the achievement of its objectives. They analyze trade concerns relating to the measures and make recommendations to facilitate implementation of the agreement.

Measures planned or implemented by one or more members may be the subject of a Specific Trade Concern (STCs) raised by one or more other members. A member which con-

siders that a measure proposed or implemented by another member constitutes a restriction on trade may raise a specific trade concern with the WTO committees. These concerns will be examined by the different committees. Over the period 1995-2019, 35 SPS and TBT STCs affecting wood and wood products were raised by member countries. For example, in November 2000, the representative of Canada raised concerns with the Committee regarding the notified measures proposed by the European Communities on solid wood packaging material. Canada indicated that the proposed measure would cover 69% of Canada's exports to the European Communities although it was aware that these materials were considered to pose a risk to plant pests. The concerns raised by Canada were shared by representatives of the USA, Korea, Japan and Chile. These concerns were resolved in March 2010, following the adoption in 2002 of International Standards For Phytosanitary Measures No. 15 (ISPM 15) for the regulation of wood packaging materials in international trade, supported by Canada, which finds no substantial difference between this international standard and the EU phytosanitary requirement for wood packaging.¹

Moreover, these specific concerns raised may relate to the implementation of the measure and not the measure itself. In October 2003, Chile and Uruguay raised a concern with other WTO members, including Canada. Chile's concern is that the adoption of ISPM 15 by Members should take into account the area of wood production and the time required for countries to adapt or comply with the standard. For Uruguay, the problem with ISPM 15 is the implementation of the standard, not the standard itself. This concern is supported by Argentina, Mexico, Paraguay and Colombia. The representative of Uruguay indicated in March 2004 that he would like more time to apply the different phases of the certification process despite the fact that he was providing national certification of wood packaging. It also expressed the need for countries lacking the necessary infrastructure to allow the valid use of alternative sanitation methods (provided for in ISPM 15, section 3.3). Argentina, China and Bolivia supported Uruguay's concerns, especially the one regarding explicit timeframes for implementation.²

SPS or TBT measures that are the subject of a specific trade concern are considered de facto restrictive and have a significant impact on trade (Curzi et al., 2020; Fontagné and Orefice, 2018; Fontagné et al., 2015).

In addition to sanitary and phytosanitary risks, the wood sector faces safety and envi-

¹<http://spsims.wto.org/en/SpecificTradeConcerns/View?ImsId=81>

²<http://spsims.wto.org/en/SpecificTradeConcerns/View?ImsId=183>

ronmental risks. Illegal logging is a major challenge for the wood and wood products trade. According to Brack (2003), "illegal logging occurs when timber is harvested, transported, bought or sold in violation of national laws. The harvesting process itself may be illegal, including corrupt means of gaining access to forests, extraction without authorization or in a protected area, cutting of protected species or extraction of timber beyond agreed limits. Illegalities can also occur during transport, including illegal processing and export, false declarations to customs and avoidance of taxes and other charges." (p.196).

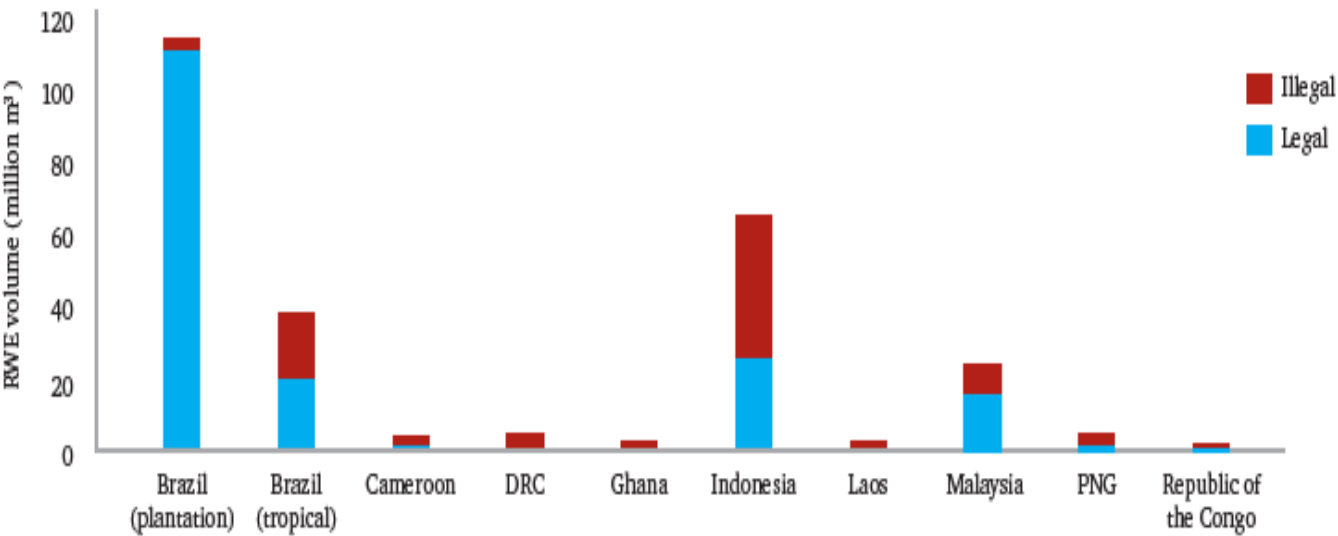
In other words, it is not just the means used without authorization and without respect for national or international rules for the production and extraction of wood from the forest, but also all the intermediate stages through which wood can reach the consumer. Considering the nature and complexity of this activity, there is no consensus on a definition at international level. Given the costly regulations and cumbersome administrative procedures involved, particularly for small-scale producers. The latter may engage in so-called informal activities on the bangs of the rules and may be considered a form of illegal logging (Hoare, 2015). The causes of this illegal activity are manifold, and are associated with a weak institutional framework, corruption, unestablished property rights and low incomes. Illegal logging and the wood trade have negative economic and environmental consequences, as they encourage massive deforestation and deprive certain populations, mainly those in developing countries, of income. World Bank (2006) reports that in the 1980s in the Philippines and Thailand, landslides, as well as a significant number of people dying and property being damaged, occurred due to deforestation related to illegal logging. Forest crime and illegal logging lead to forest degradation that jeopardizes biodiversity, livelihoods, and the social and economic security of local communities. It raises carbon emissions and global climate change costs (World Bank, 2006).

Illegal logging is a major global threat and problem. The environment, the economy, equity, and sometimes politics can all be harmed by this phenomenon, which affects many people (Contreras-Hermosilla et al., 2008). It is difficult to estimate and assess because it is hidden, outside the system, and takes place in sometimes unknown circumstances. In this regard, Wynet (2002) points out that there is no information on the overall share of illegal logging in the national and international timber trade. However, some authors have attempted to estimate illegal logging. Figure 6, shows the estimated production of timber

of nine countries considered to be the main producer of illegal timber. Indonesia (about 50%), Brazil (25%), and Malaysia (10%) with a large forest area are the main countries with a large share of illegal timber, followed by countries such as the Democratic Republic of Congo (DRC), Ghana, Laos, Papua New Guinea, and the Republic of Congo with less timber production but with very high proportions of illegal timber in their total production. Cameroon also has a large share of illegal timber.

Figure 6: Estimated production of legal and illegal timber in the nine producer countries, 2013.

Source: Hoare (2015)



To control and combat this phenomenon, national and international measures, actions and policies have been put in place. In timber-producing countries where illegal logging takes place, a number of initiatives have been taken, particularly in the legal sphere, to strengthen compliance with laws and regulations condemning illegal logging. For example, Indonesia has implemented repressive measures such as arrests and seizures, while Malaysia has turned to control and surveillance measures and regulation (Brack and House, 2007). In addition, some timber-consuming or importing countries have also introduced policies to combat illegal logging. These policies tend to focus on controlling international trade and bi-

lateral agreements with producer countries, with the aim of promoting trade in legal timber. In the USA, these efforts to combat illegal logging came to fruition in 2008 with the amendment of the Lacey Act. The law was amended to cover timber and timber products (paper, pulp, furniture). It thus prohibits interstate and international trade in these illegally obtained products (Prestemon, 2015). In practice, this law is not based on conformity assessment procedures attesting to the legality of products, but rather on due diligence (having information on product characteristics) applied at the whim of the buyer or importer who, depending on its specific features (risk, relationship with suppliers), ensures that illegal wood and wood products do not enter the market (EFI, 2013). The European Union (EU) launched The EU Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan in 2003. Through two main measures: Voluntary Partnership Agreements (VPAs) and the EU Timber Regulation (EUTR), this plan aims to combat illegal logging. VPAs are bilaterally negotiated agreements between the EU and an exporting partner country outside the EU, based on the legislative and regulatory framework of the partner countries. The aim is to prevent the import of illegal timber from these countries into the EU, while promoting good forest governance. The definition and verification of legality in relation to timber is based on the national legislative and institutional framework of partner countries. However, verification of legality requires the intervention of an independent body to ensure compliance with the terms of the agreement. The EUTR was adopted in 2010 and came into force in 2013. Like the Lacey Act, this regulation is based on due diligence for wood and wood products. These products are considered legal when they comply with the laws of exporting partner countries. In a similar vein to the EUTR, Australia's Illegal Logging Prohibition Act came into force in 2014 and aims to prohibit the trade of illegal timber products in Australia (Fernández et al., 2021). In addition, with the aim of promoting legal and sustainable timber trade through certification and other legality verification methods, measures in line with the 2006 Public Procurement Law have been put in place by the Japanese government. ("Goho-wood") (Jonsson et al., 2015). Similarly, South Korea's Sustainable Timber Use Act was introduced and went into effect in 2018. In light of these actions, it is clear that combating illegal logging remains a major concern.

Illegal logging is by nature difficult to detect. Illegal timber and forest products move from one country to another through international trade. Regulations are therefore needed not only to protect consumers and prevent environmental risks, but also to promote the legal logging and trade of wood and wood products.

Forest certification can be used as a tool to comply with these regulations. With a view to protecting the environment, combating deforestation and ensuring sustainable forest management, certification is seen as a tool for achieving a balance between exploiting forests and providing forest services, promoting forest management and combating deforestation. Unlike a standard, certification involves a third party, whose role is to guarantee, through the certificate, that the goods and services comply with the technical requirements. The certificate is issued by an organization that has no direct economic interest in the seller or consumer. Certification appears as a market tool, offering greater transparency on the quality of the product, service or production process, and reinforcing trust between buyer and producer. A certificate differs from a label in that the latter is aimed at the end consumer, whereas a certificate focuses on the process and the relationship between buyer and seller (Dankers, 2004). Certification is a voluntary, heterogeneous procedure that depends on the certification body. It is granted for a defined and restricted period, during which audits and controls are carried out by the certifier. Internationally, there are two main types of forest certification.

The Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification schemes (PEFC) are the two main sustainability certifications. Numerous initiatives, such as government reforms, have been taken in various countries. Non-governmental organizations and environmental associations have also promoted the idea of global forest certification. Thus, in 1993, FSC certification was created on the initiative of companies and environmental associations. In Europe, in 1999, PEFC was created on the initiative of foresters, associations and stakeholders in the forest wood sector, with the aim of taking account of specific European features. These stakeholders considered that other certifications, in particular FSC, were not suitable for Europe (Gillon, 2001). Although PEFC was created to reflect European realities, it has become a global system, operating in several countries. The FSC's mission is to promote ecologically appropriate, socially beneficial and economically viable forest management to meet the needs of future generations. Its activities focus on three main areas: standards development, accreditation and brand assurance. FSC takes into account all stages of production, from processing to distribution in its certification process, awarding certificates for forest management, chain of custody and controlled wood. FSC forest management certification is based on ten criteria that apply to all types of forest

³. Chain of custody certification is aimed at companies involved in the production, process-

³These criteria are: "respect for the law, workers' rights and working conditions, rights of indigenous peoples,

ing and distribution of wood, paper. It is carried out by an accredited third-party certification body. FSC has 159 million hectares of certified forests and 58,298 certified companies. Three types of label are affixed to products, depending on their composition: FSC 100%, FSC mixed and FSC recycled ⁴.

PEFC aims to guarantee sustainable forest management in all its dimensions: societal, environmental and economic. Its mission is to establish rules and criteria for sustainable forest management for all stakeholders in the forest wood sector (production, processing, distribution), and to guarantee their proper application. PEFC is based on the involvement of all industry stakeholders in its mission, and on the general interest, so it applies internationally, nationally and regionally, with certification rules specific to each country. Like FSC, PEFC issues forest management and chain-of-custody certificates to companies. Forest certification guarantees that stakeholders (foresters, producers) apply and respect the rules of sustainable management and the social, environmental and economic functions of forests.

The chain of custody is provided by a third-party certification body and is aimed at wood processing and distribution companies. It enables certified wood to be traced from upstream to downstream, and to be marketed as a certified end product. PEFC is the most widespread in the world, with 280 million hectares of PEFC-certified forests worldwide by December 2023, and 20,000 companies certified for the chain of custody ⁵. [Figure 7](#) and [Figure 8](#) show the evolution of forest area certification worldwide. It can be seen that between 2000 and 2005, global forest area certification tripled.

relations with communities, benefits generated by the forest, environmental values and impacts, management planning, monitoring and evaluation, high conservation values and implementation of the certificate"

For more information, see: <https://fsc.org/en>

⁴<https://connect.fsc.org/impact/facts-figures>

⁵<https://www.pefc.org/>

Figure 7: PEFC certified forest area growth.

Source: PEFC (2023).

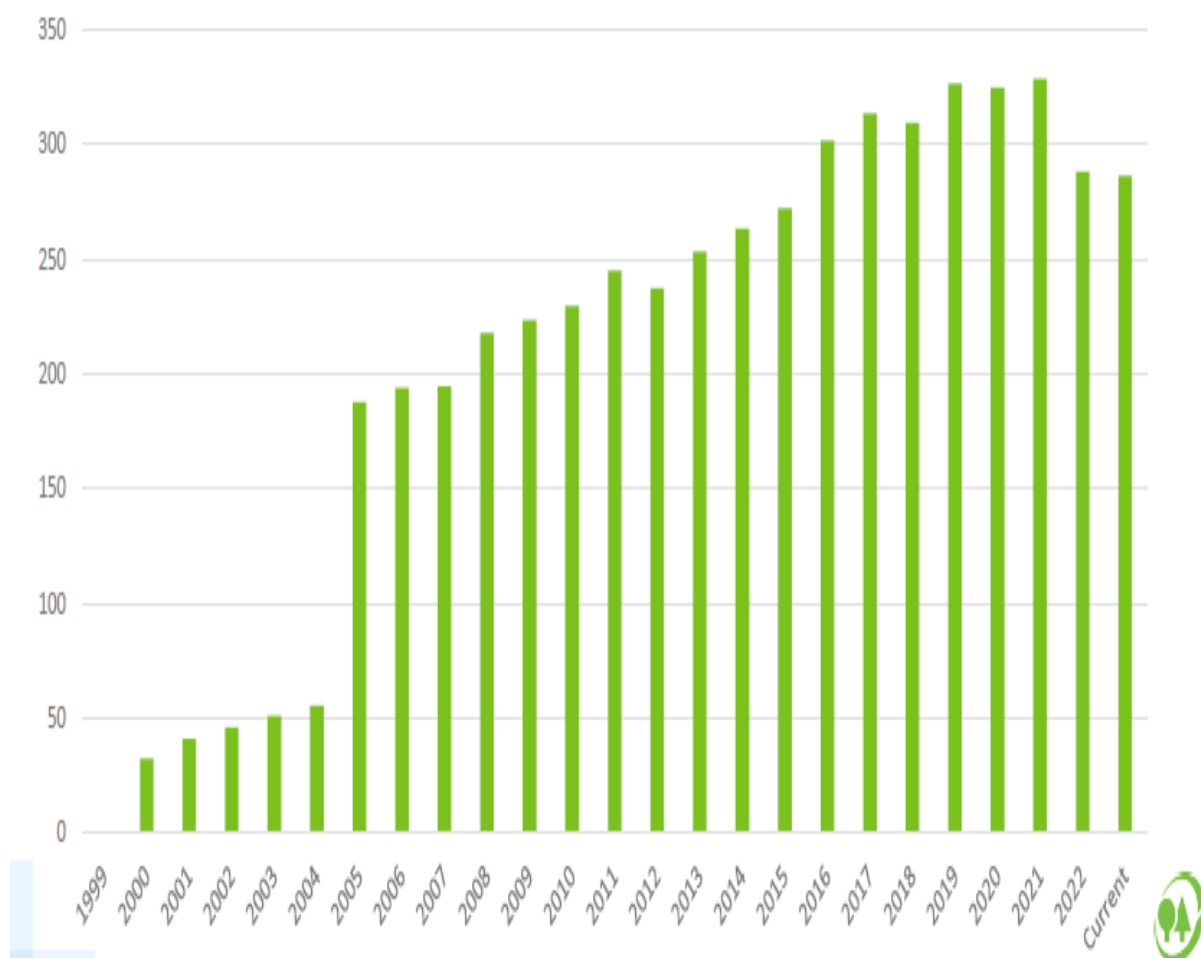
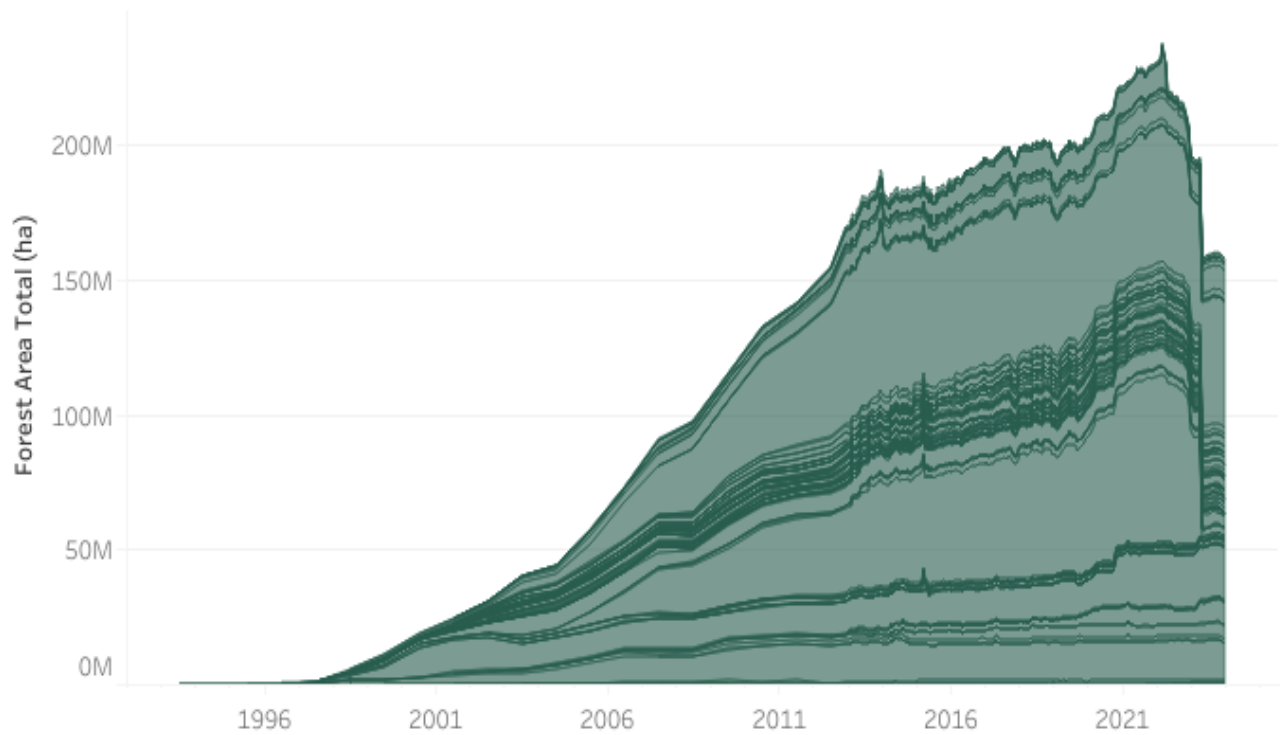


Figure 8: Forest management FSC certified area.

Source: FSC Website <https://connect.fsc.org/impact/facts-figures>



In recent years, international trade has become increasingly regulated and certified. The wood sector is no exception, and is subject to them. It is undeniable that these trade policy instruments have an impact on international trade. The literature on the impact of trade policies on trade is growing. But there is a gap in the literature on the specific effects of these policies on the wood sector. Most studies focus on the agri-food sector (Crivelli and Gröschl, 2016; Disdier et al., 2008; Murina and Nicita, 2017; Peci and Sanjuán, 2020; Shepotylo, 2016). Among the studies focusing on the wood sector, L. Sun et al. (2010) analyze the effect of NTBs on global forest products and compare these impacts to those of tariffs. To do this, the authors use a simulation model, a partial equilibrium model of forest products in which they incorporate information on tariffs and NTMs. The authors emphasize the importance of NTMs for forest products and note that the impact of tariff and NTM reduction often differs by region and product. In a similar vein, J. A. Turner et al. (2008) analyze the impact of NTB removal on New Zealand's exports of remanufactured wood products (prefabricated housing and carpentry and joinery) to its three main partners, China, the USA and Japan. The authors use an extended economic model of international trade in secondary processed wood products in the structure of the Global Forest Products spatial equilibrium model. The authors show that the removal of NTBs, which account for a large portion of production costs, would be more beneficial to New Zealand exporters. Thanh Van et al. (2021) analyze the impact of factors including the Natural Forest Closing (NFC) policy and SPS measures on the value of non-timber forest product (NTFP) exports for Vietnam. They find that SPS measures significantly reduce and the NFC policy increase exports. Some more descriptive studies analyze the evolution of NTMs. D. H. Cohen et al. (2003) compare the evolution of NTMs in the agricultural sector with some of the factors that led to the adoption of NTMs in the lumber sector.

No consensus has been reached on their effects on international trade. There are two main effects: a positive effect related to the fact that compliance with these measures reduces information asymmetries on product safety and quality, which will encourage greater consumer demand, thus offsetting the costs of adapting to these measures. A negative effect related to high adaptation costs and lengthy administrative procedures that limit trade.

This thesis contributes to this literature by providing new insights into the relationship between trade policies and international trade. The objectives of this thesis are: (i) to understand the relationship between regulations, certifications and international trade, (ii) to

identify the specific effects of these trade policy instruments on the wood sector.

This analysis is of real interest for a booming sector that contributes to the economy and environmental protection. It also raises economic policy implications in terms of harmonizing regulations between countries, facilitating administrative procedures linked to product compliance, and the need to develop forest certification.

In the first part of this thesis, divided into chapters 1 and 2, we study the relationship between SPS and TBT measures and trade in wood and wood products. We answer the following questions: (i) what is the impact of SPS and TBT measures, distinguishing between technical regulations and conformity assessment procedures, on trade in the forest-wood-paper sector; (ii) what is the impact of restrictive SPS measures on trade in wood and wood products.

In the second part (chapters 3 and 4), we analyze how policy instruments related to sustainability, illegal logging and sustainable forest management impact international trade in wood and wood products. Chapter 3 aims to identify the impact on trade in timber and timber products of regulations aimed at prohibiting illegal logging and combating deforestation. Chapter 4 assesses the impact of forest certification as a market tool on exports.

In the **first chapter**, we analyze the impact of SPS and TBT measures on trade in the forest, wood and paper sector. Disdier et al. (2008) have shown that SPS and TBT measures have an impact on trade flows. This analysis extends the literature on the relationship between trade policy and trade by assessing how SPS and TBT measures (distinguishing between technical regulations and conformity assessment procedures) affect trade flows in the forest products sector. This chapter differs from the previous literature not only by focusing on the forest-wood-paper sector, but also by taking a broader view of the effects of these measures according to the level of development of importing and exporting countries. To do this, we use an empirical method, the gravity model, to estimate the effects. Our results show that trade flows increase with SPS and TBT conformity assessment procedures and TBT technical regulations. When we take into account countries' level of development, we find a differentiated impact. In particular, trade with exporting developing countries declines when importing developed countries implement SPS and TBT conformity assessment procedures and SPS technical regulations. The opposite occurs when the measures in place are

TBT technical regulations. In other words, TBT technical regulations implemented by importing developed countries increase trade flows with exporting developing countries, as do SPS and TBT compliance procedures implemented by developing countries. Trade with developed exporting countries increases with SPS and TBT conformity assessment procedures and TBT technical regulations, regardless of the level of development of the importing country imposing them. By analyzing regulatory differences or similarities between countries using bilateral indicators, we show that developed countries have greater regulatory intensity than developing countries. This result suggests that developing countries will face technical and financial difficulties in complying with measures imposed by developed countries.

Measures introduced or in the process of being introduced by countries may be the subject of one or more trade concerns within WTO committees. Measures that are the subject of trade concerns are considered *de facto* to be trade-restrictive. We contribute to this statement in our **second chapter** by empirically analyzing the impact of restrictive SPS measures on trade in wood and wood products. We assess the effect of these restrictive SPS measures on both the value of trade and the duration of trade over the period 2000-2019. Using the Kaplan-Meier estimator, we analyze the duration of trade in our sample. Our results show that trade in wood and wood products is short-lived. We find that restrictive SPS measures have a negative impact on the value of trade. Based on a discrete-time model, we find no significant impact of these measures on the probability of trade survival.

In **chapter 3**, we analyze the impact on trade of timber regulations aimed at combating illegal logging and its consequences, and promoting the legal timber trade. Illegal logging and its consequences, such as deforestation, are a threat to our society. To guard against this risk, several countries, including the USA, the EU, Australia and the Republic of Korea, have introduced regulations on the timber trade. Few studies have analyzed the effect of these measures on trade in timber and timber products. This chapter examines the effects of the implementation of these regulations on imports of timber and timber products from timber-producing and timber-processing countries where illegal logging is widespread. Our analysis focuses on the period 1995-2019, using a method combining Gravity's approach with a matching such as entropy balancing. Our results show a negative impact of the implementation of these regulations on imports of timber and timber products.

Chapter 4 analyzes the impact of forest certification on trade. We focus on the use of

certification as a large-scale market tool. The literature has paid only very limited attention to the effects of forest certification on trade flows. This analysis is the first to identify the effects of forest certification on trade using firm-level data and controlling for firm heterogeneity. We study the impact of the difference in the level of forest management certification between exporting and importing countries on the value of trade. We use data on exports of wood and wood products by French firms, focusing on PEFC certification. We find that exports increase when the level of forest management certification in the exporting country increases relative to that of the importing countries. This effect is weaker the larger the size of the firm. Our results show heterogeneous effects according to geographical area, income level of destination countries and product category.

Part 1 Technical measures : SPS and TBT and Trade in Wood and Wood products

Technical measures govern international trade and are applied to achieve legitimate objectives such as consumer health and safety, plant and animal protection and environmental protection. There is no consensus on their effect on trade. This part of the thesis aims to identify the specific impact of SPS and TBT on trade in wood and wood products, and includes two chapters. In the first chapter, we analyze the impact of SPS and TBT measures, distinguishing between technical regulations and conformity assessment procedures, on trade in the forest-wood-paper sector as a whole. We analyze the heterogeneity of the effects of these measures according to countries' level of development. Using bilateral indicators, we identify similarities or differences in regulatory patterns between countries. In the second chapter, we analyze the impact of so-called restrictive SPS measures that have been the subject of at least one Specific Trade Concern (STC) on the value and duration of trade in wood and wood products. Using the Kaplan-Meier estimator, we investigate the duration of trade in wood and wood products.

The Impact of Technical Barriers to Trade and Sanitary and Phytosanitary Measures on Trade in the Forest-Wood-Paper Sector

1.1 Introduction

For several years, the reduction of tariff barriers and trade liberalization have been at the heart of debates and current events. As a result of the various multilateral negotiations conducted under the General Agreement on Tariffs and Trade (GATT) of 1947, there has been a significant reduction in tariffs with slower progress in developing countries.

The Uruguay Round of 1986-1994 was the subject of major trade negotiations and led to real progress in trade liberalization in various areas. The negotiations favored a reduction in the progressiveness of tariffs imposed by developed countries with a 30 percent reduction in wood-based panels, a 50 percent reduction in semifinished products, a 67 percent reduction in wood articles and a more significant reduction in pulp and paper products (Barbier, [1995](#)).

Although there has been a considerable reduction in tariff barriers, this has been followed by the implementation of nontariff measures (NTMs) that can have a greater impact on trade.

At the international level, countries have used these measures to achieve their objectives and compensate for the reduction in tariffs. However, the motivations behind the introduc-

tion of NTMs are not explicit. Such measures can be either legitimate to correct market failures or protectionist to protect domestic producers or industries (WTO, 2012). Depending on the motivations of governments, these measures may have different effects on trade. In practice, it is difficult to determine the motivations of governments, especially when these measures intended to achieve legitimate objectives are in fact used for national interests. This makes it difficult to determine the impact of such measures on trade.

NTMs are therefore called nontariff barriers (NTBs) to emphasize the restrictive and protectionist nature of such measures. Nicita and Gourdon (2013) point out that this designation of NTMs as NTBs is incorrect. NTMs can take different forms, and the term NTB is very restrictive, as it refers to discriminatory NTMs imposed by governments to favor domestic over foreign suppliers. In addition, it should be noted that these measures, in particular, the technical measures increasingly used by governments, apply to the forest-wood-paper sector and are crucial for international trade in goods and services. These technical measures are sanitary and phytosanitary (SPS) measures that aim to protect human, animal and plant life and health, and , technical barriers to trade (TBTs) cover technical regulations, standards and conformity assessment procedures developed to achieve legitimate objectives (environmental, safety, and consumer protection) other than those covered by SPS measures.

International trade in forest products continues to grow. Economic growth and environmental concerns have led to a renewed interest in wood. Domestic and foreign investment has flowed into the sector, particularly in emerging economies (FAO, 2007). According to the Food and Agriculture Organization (FAO), the global trade in industrial wood increased by 7% to a peak of 138 million m³ and global trade in wood pulp increased by 2% to 66 million tons.¹ This expansion has been accompanied by a preponderance of NTMs governing trade in this sector, which presents important environmental issues. Forest products such as raw and sawn wood can contain pests that can pose risks to plant preservation and human and animal health. In UNCTAD and World Bank (2017) it is shown that NTMs are more important than tariffs for wood products. The share of trade subject to NTMs in this sector is over 60 percent, and the share of imported products affected by one or more NTMs is approximately 40 percent. The authors also point out that the most commonly used measures are SPS measures and TBTs. In Bourke (2000) it is stated that phytosanitary and technical regulations and standards have the greatest effect on forest products.

¹<http://www.fao.org/3/ca7415fr/ca7415fr.pdf>

Given the importance of such technical measures to this sector, it is important to determine their effects, especially on trade. We analyze the impact of SPS and TBT measures imposed by importing countries on trade in the forest-wood-paper sector.

In the economic literature, some authors have analyzed the effect of NTMs on trade, and in particular, that of SPS and TBT measures. There is no consensus on the impact of such measures on trade, which remains mixed. The literature shows both positive and negative impacts of these measures. Disdier et al. (2008) find a negative impact of SPS and TBT measures on trade in the agricultural sector. Crivelli and Gröschl (2016) find a negative impact of SPS measures on the probability of trade subject to market entry and a positive impact on the volume of trade in agricultural and food products. The impact of SPS and TBT measures may be different depending on the sector under consideration and the level of development of exporters. For example, Fontagné et al. (2005) find that SPS and TBT measures have a positive impact on industrial products and a negative impact on food products. Developing countries have been highlighted as the exporters most affected by these measures imposed by importers. Disdier et al. (2008) emphasize that exports from developing countries are significantly more affected than those from developed countries.

In our study, we use an empirical model, the gravity model, which allows us to determine the impact of SPS and TBT measures on trade in the sector as a whole and for a set of countries. Our contribution to the literature is as follows: to our knowledge, we are the first to use a gravity model to determine the effects of SPS and TBT measures on trade in the forest-wood-paper sector as a whole and for a set of countries by distinguishing between technical regulations and conformity assessment procedures. In addition, we analyze the effects according to the level of development of importing and exporting countries. To explain the heterogeneous effects according to the level of development of countries, we calculate bilateral indicators of differences/similarities in regulatory structures between importing and exporting countries according to their levels of development. The underlying idea is that given the World Trade Organization's (WTO's) principle of nondiscrimination between domestic and foreign products, import measures should apply equally to domestic producers (UNCTAD, 2017). Thus, to the extent that importing and exporting countries show very few differences in their regulatory structures, one would think that exporting countries would be more likely to comply with measures imposed by importing countries with a similar regulatory structure to their own and to which they export their products. In addition, unlike

most studies (Disdier et al., 2008; Fontagné et al., 2005) and building on the work of Peci and Sanjuán (2020), we construct panel data with information from TRAINS (Trade Analysis Information System) database of the United Nations Conference on Trade and Development (UNCTAD). We also take into account bilateral and temporal dimensions. We calculate an indicator, regulatory intensity, which corresponds to the number of measures imposed on a product in the forest-wood-paper sector. This indicator highlights the fact that the same product may be subject to different SPS or TBT measures and thus the prevalence of these measures in this sector. This panel dimension allows us, unlike cross-sectional data, to correct for potential endogeneity biases related to trade policies.

Our results show that SPS and TBT conformity assessment procedures and TBT technical regulations increase trade flows. We find that the effect of these measures on trade varies depending on the level of development of countries imposing them, particularly for imports from developing countries. SPS and TBT technical regulations imposed by developing countries do not have a significant impact on imports from developing countries, while SPS and TBT conformity assessment procedures contribute in increasing them. In contrast, SPS and TBT conformity assessment procedures and SPS technical regulations imposed by developed countries tend to restrict trade with developing country exporters, while TBT technical regulations tend to increase it. The positive effect of SPS and TBT conformity assessment procedures and TBT technical regulations on imports from developed countries is not different depending on the level of development of countries applying these measures. We analyze the similarities and differences of regulatory models using bilateral indicators to explain these results, and we find that the regulatory intensity of developed countries is higher than that of developing countries. Similarly, regulatory overlap, i.e., measures applied by importers that are also applied by exporters, is slightly lower between developed importing countries and developing exporting countries. This suggests that it will take more financial and technical resources for developing countries to comply with measures imposed by developed countries. The remainder of this paper is structured as follows: [section 1.2](#) provides a literature review, and [section 1.3](#) and [section 1.4](#) present our data and econometric model, respectively. In [section 1.5](#), we present our baseline results and those of our sensitivity and heterogeneity analyses. We conclude in [section 1.6](#).

1.2 Literature Review

Finding an appropriate measure to identify NTMs remains one of the most important challenges faced by authors studying their impact on international trade. Indeed, these measures can take different forms and have different effects on trade flows (Ederington and Ruta, 2016), which complicates their identification. Several approaches have been highlighted as means to identify and estimate the impact of NTMs on trade.

Beghin and Bureau (2001), Bora et al. (2002), Deardorff and Stern (1998), and Ferrantino (2006) review different means to quantify NTMs and their impact. Approaches used to identify nontariff trade measures and their impact mainly include the inventory-based approach, surveys, gravity models, the price wedge method and price comparison measures.

The inventory method involves identifying observed NTMs by sector. This method provides statistics or variables such as the total number of standards in effect, documents detailing standards, notifications of TBT measures, and frequency and coverage indexes. Swann et al. (1996) analyze the impact of standards on trade performance in the United Kingdom (UK). Using data collected from the Perinorm database, the authors use the total number of British and German standards as a measure of these standards in their study. The Perinorm database provides information on standards, draft standards and technical regulations of countries and international organizations. The authors find that standards improve the balance of trade and can also make the market more open. Moenius (2004) uses the number of documents that detail standards as a measure. The authors examine the impact of country-specific and bilaterally shared product and process standards for 471 industries of 12 countries for 1980-1995. The results show that bilaterally shared standards are favorable to trade and that standards specific to importing countries reduce imports for agricultural goods and promote trade in the manufacturing sector.

Unlike Moenius (2004) and Swann et al. (1996), who use the Perinorm database to quantify NTMs (standards), some authors, such as Bao and Qiu (2012), use TBT notifications from WTO member states. Indeed, the TBT and SPS Agreements stipulate that member states have an obligation to notify the WTO Secretariat or inform other members of the development of regulations that differ from international standards or that may affect trade. Apart from counting the total number of observed standards or notifications, more sophisticated statistics such as the frequency index and coverage ratio can be developed to quantify these mea-

asures. The frequency index represents the share of products affected by one or more NTMs, and the coverage ratio represents the share of trade subject to these measures (UNCTAD, 2018). Disdier et al. (2008) use these indexes to identify countries that use SPS and TBT measures intensively and the products and exporters most affected. According to the authors, these statistics only take into account the presence or absence of NTBs, and the coverage ratio may be subject to endogeneity bias when NTMs have an impact on trade. One of the limitations of the inventory approach is that it does not quantify the effects of regulations on trade (Beghin and Bureau, 2001). The method also ignores the restrictiveness of NTMs (Ederington and Ruta, 2016).

A second approach is to use survey data. The main advantages of this approach are that it quantifies difficult-to-measure NTMs, identifies measures that have a greater impact on producers, and provides accurate and relevant information on standards (Beghin and Bureau, 2001). The high cost of this approach and the potential biases (selection and perception bias) associated with surveys remain the main limitations of this approach.

Both approaches are of interest for quantitative or qualitative analyses. The indexes calculated through these approaches are used as explanatory variables in gravity models to determine the impact of NTMs on trade. The gravity model is used to predict the volume of trade between countries using variables that measure the economic size of countries, the distance between them and other geographic and cultural variables such as common language (Candau and Rey, 2014). Melo et al. (2014) estimated the effects of sanitary, phytosanitary and quality standards on Chilean fresh fruit exports. From the information obtained from the surveys conducted, the authors calculate a multidimensional perception index of the stringency of trade requirements that they use as an independent variable in a gravity model.

Bao and Qiu (2010) analyze the influence of technical barriers imposed by China on these imports. The authors use the frequency index and coverage ratio to quantify technical barriers to trade and find that technical barriers to trade reduce trade in agricultural products but increase trade in manufactured goods. Otsuki et al. (2001) use a gravity model to estimate the impact of European regulations on groundnut exports from African countries. Unlike studies that use frequency or coverage indexes, these authors use a measure of maximum allowed aflatoxin levels to quantify the severity of food standards.

Another means of accounting for NTMs is to determine the price range or tariff equivalent (AVE) of NTMs. The price wedge method and price comparison measures are based on the idea that the effect of NTBs can be estimated according to their impact on the domestic price relative to a reference price. For Deardorff and Stern (1998), the most accurate way to apply this approach is to compare the price that would prevail without NTBs to the price that would prevail on the domestic market in the presence of NTBs if the price paid by suppliers remained unchanged. Since these prices are unobservable, measures of NTBs are obtained by comparing domestic and foreign prices in the presence of NTBs.

Calvin and Krissoff (1998) use this method to calculate a tariff equivalent of technical measures. The price wedge is calculated as the difference between the Japanese domestic price and the price of similar U.S. products delivered to Japan. This price is divided into the known tariff rate and the technical barrier tariff equivalent, which is the residual. This method has a limitation that stems from its underlying assumptions. The method assumes that domestic and imported goods are perfect substitutes, which is a rather strong assumption and not very viable in practice. Additionally, this method does not take into account heterogeneities, such as differences in quality that may exist between the two goods.

Tariff equivalents of NTMs can also be calculated using import demand elasticities (Disdier et al., 2008; Ferrantino, 2006). This approach developed by Kee et al. (2009) involves, on the one hand, estimating for each country the quantitative impact of NTMs (basic NTBs and domestic agricultural support) on imports at the six-digit harmonised system (HS) tariff line. On the other hand, this quantitative impact is converted into a price equivalent (or AVE) using import demand elasticities. The authors use the comparative advantage approach of Leamer (1990) based on the Heckscher-Ohlin model to determine the quantitative impact of NTBs.

All of these identified approaches have been used in the literature to quantify the impact of SPS and TBT measures. Among the studies that have analyzed the effects of these measures on trade, mixed results and varied and complex effects on trade are noted.

We observe a positive effect of these measures on the volume of trade or the intensive margin and a negative effect on the probability of trading or the extensive margin (Bao and W.-C. Chen, 2013; Bao and Qiu, 2012; Crivelli and Gröschl, 2016) and on the volume of trade (Disdier et al., 2008; Karov et al., 2009; Otsuki et al., 2001).

Moreover, unlike these studies that focus on country-level trade flows, several authors use

firm-level data to determine the impact of NTMs on trade. These disaggregated data make it possible to highlight how firms' export decisions and trade patterns are affected by such measures. M. X. Chen et al. (2008), using the World Bank's TBT survey database, show that the impact on the intensive and extensive margins of developing country firms' exports depends on the types of standards adopted. The authors' results suggest, among other things, a positive correlation between quality standards and average trade volume and the number of export products and markets. Fontagné et al. (2015) study the effect of SPS concerns raised in WTO SPS committees on different components of trade, such as the probability of exporting and exiting the export market, exported value, and export prices. The authors find a negative effect of SPS concerns on exporters' participation in foreign markets imposing SPS measures and on export value and a positive effect on export prices. This negative effect is less significant for large firms. In the same vein, Fontagné and Orefice (2018) analyze the effect of TBT concerns on the export margins of heterogeneous French firms focusing on the export reorientation of multideestination exporters. The authors show that the effect of these measures on participation is amplified for multideestination firms. Fernandes et al. (2015) analyze the impact of importing countries' standards for agricultural and food products on export values and quantities for the 2006-2010 period. Their analysis differs from the majority of studies that use firm-level data in that they create indexes to quantify the absolute stringency of these standards and focus on differences in the rigor of standards between the importing country and exporting country. Overall, the authors find that the extensive and the intensive margins of exports are negatively impacted by the stringency of SPS measures.

The negative impact highlighted in the literature is explained by the fact that these measures entail fixed costs associated with adapting the product to these standards. Thus, to access markets, exporters have to bear these costs, which can discourage market entry. This effect is all the more important for developing countries with limited financial and technical means to adapt their production processes to comply with NTMs. The authors' argument for the positive impact is that these measures provide information about product quality and safety to consumers, which increases their confidence and demand for the product. The increase in demand and market share offsets the fixed costs of adapting and conforming products to standards. The trade performance of existing exporters may also improve because technical barriers to trade can discourage potential competitors from entering their markets or by driving marginal exporters out of the market (Bao and W.-C. Chen, 2013). In addition,

the impact of these measures can vary depending on the sector under consideration and the specificity of the measure. Sithamaparam and Devadason (2011) study the impact of NTMs on Malaysian exports to the main traditional markets of the European Union (EU), Japan and the Association of Southeast Asian Nations (ASEAN) for 2000-2013. Using a unidirectional gravity model, the authors show that NTMs have a negative impact on Malaysian exports of agricultural products and a positive impact on industrial products. Schlueter et al. (2009) analyze the trade effects of different SPS regulations in the meat sector. Data on regulations were grouped according to SPS areas and their policy objectives. The results show a positive effect of SPS on trade. At the disaggregated level of SPS measures, the authors find that disease prevention measures, tolerance limits for residues and contaminants, conformity assessment and information requirements promote trade while measures related to production process requirements and the handling of meat after slaughter restrict trade.

These studies show the effects of SPS and TBT measures on trade in agricultural and food products. However, similar to the agricultural sector, the forest-wood-paper sector is also subject to these measures that govern trade within it. Our study thus focuses on this sector, whose trade is developing at the same time as technical measures, and determines associated effects on trade, also according to the level of development of importers and exporters. SPS and TBT measures fall under two broad categories: technical regulations and conformity assessment procedures. Technical regulations are documents that define the characteristics of a product or production process. Conformity assessment procedures refer to procedures that aim to determine compliance with or the respect of these technical regulations. Given the specificities of these two broad categories of measures, we determine their distinct impacts on trade. Our study is related to that of Peci and Sanjuán (2020), who construct panel data and a regulatory intensity indicator through the UNCTAD Trains database to account for endogeneity problems present in cross-sectional analyses. To account for these technical measures in our analysis, we use country-level data and specific the UNCTAD Trains database, which is more comprehensive than the WTO Member States' notification database, and we construct an indicator for the number of measures applied to a specific product. Unlike the frequency and coverage indices, this indicator allows us to focus on regulatory intensity within the sector. We use a gravity model estimated with a pseudo-Poisson maximum likelihood (PPML) approach. To explain heterogeneous effects of the level of development of importers and exporters, we also calculate bilateral indicators of

differences/similarities in regulatory models or structures between importing and exporting countries according to their levels of development.

1.3 Data

Our analysis involves determining the impact of SPS and TBT measures applied in the forest-wood-paper sector. Our data on these technical measures come from the TRAINS UNCTAD database. The data are available in both searchable and research versions. In this study, we use the researcher database. This database provides information on NTMs imposed by countries and that are in force.

SPS and TBT measures can be imposed unilaterally on any partner or bilaterally on specific countries in rare and exceptional cases. For each type of measure, information is available on the country notifying the measure (importing country), the affected product (at the six-digit level of the tariff line of the HS classification), the affected partner country, and the nomenclature of the measure. Also included is information on the year of data collection, the number of separate measures imposed, the first year for which there is a measure on the product, and the last year for which a measure can be reported as not being enforced, if applicable. The Harmonized Commodity Description and Coding System or Harmonized System (HS), which came into effect in 1988, is an international nomenclature governed by the International Convention on the Harmonized Commodity Description and Coding System developed by the World Customs Organization. The purpose of this nomenclature is to classify products traded in international trade on a common basis among countries.

According to the HS classification, the forest-wood-paper sector mainly includes products from chapters (HS2) 44 to 49 and 94, and we consider these chapters as subsectors.² Chapters 44 to 46 refer to “wood, wood charcoal and articles of wood; cork and articles of cork; and articles of straw and plaiting materials”; Chapters 47 to 49 refer to “pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard; and paper and articles” and Chapter 94 refers to “furniture; medical and surgical furniture and bedding, mattresses, mattress supports, cushions and similar articles”. Furniture and parts of furniture of wood are to be found mainly in headings 9401 (seats), 9403 (furniture) and 9404 (bedding)³. We consider data compiled of the SPS and TBT

²The Harmonized System has been updated several times and most recently on January 1, 2017.

³In chapter 94, we consider only wood furniture and parts of wood furniture.

measures that apply to the products covered by these chapters and the headings above.⁴ The TRAINS database has an advantage over the WTO notifications. The UNCTAD complements notifications from WTO member countries and uses an approach based on active data collection based on an independent review of legislation. This provides comprehensive information on the regulations in place at the time of collection (UNCTAD, 2018). However, the TRAINS database has some limitations. As the data included in this database provide information on measures that were in place at the time of data collection, we do not have information on measures that existed and were replaced prior to collection, which can make panel analyses difficult to implement. Adopting the same strategy as Peci and Sanjuán (2020), we use information on both the year for which there is a measure on the product and the last year for which a measure can be reported as unenforced to construct a panel database for the period of 2012-2015. These panel data therefore provide information about the measures in effect during this period. However, given the limitations of this database, it still only provides an approximation of time series (Peci and Sanjuán, 2020). To account for the number of measures, we calculate an indicator called "regulatory intensity" for the number of measures that affect a given imported product. Based on the number of measures provided in the TRAINS database and taking into account bilateral and unilateral measures, we calculate the number of measures imposed by an importer on an exporter for each year of the 2012-2015 period.⁵

UNCTAD's classification is structured in chapters including the letters A to P. Chapters A and B group SPS measures (A) and TBTs (B). These measures are grouped into two main categories: technical regulations and conformity assessment procedures classified in different sections. For SPS and TBT measures, technical regulations are the most used by importing countries.⁶ For SPS measures, the most common technical regulations are in the form of "Special authorization, registration requirements for importers, packaging requirements, hygienic requirements, storage and transport conditions'. The regulation related to treat-

⁴In the database, the year of data collection for NTMs in several countries is between 2012 and 2016 inclusive. The European Union is considered a single country. In our analysis, we do not consider the European Union as a single region. We consider each member separately and replicate this information aggregated for each member. Similar to Disdier et al. (2008), we exclude intra-EU trade flows from our sample, as EU member states apply the principle of mutual recognition to SPS and TBT regulations.

⁵We do not take into account, for each year considered, measures that may be reported as not being implemented in these years.

⁶SPS measures classified under sections A1-A6 are technical regulations, and section A8 includes conformity-assessment procedures related to these regulations. TBT measures classified under sections B2-B7 are technical regulations, and section B8 includes conformity-assessment procedures related to these regulations. Those under section B1 must result from the enforcement of both types of measures.

ment for the elimination of plant and animal pests mainly affects subsector 44: “Wood and articles of wood and wood charcoal ”. Indeed, roundwood presents more risks than processed wood. Logs may contain pests that can spread from one country to another through trade. To prevent the spread of these pests, specific wood treatments, such as heat treatment, are necessary and imposed by countries.

For TBT measures, these most widespread technical regulations take the form of “ Tolerance limits for residues or contamination, labelling, marking, packaging requirements, product quality or performance requirements’.” Regarding conformity assessment procedures, the most common procedures affecting wood products are: “Product registration, testing, certification, inspection and traceability information requirements’.”

Furthermore, we analyze which subsectors (HS2) are most affected by these technical measures by distinguishing between technical regulations and conformity assessment procedures (SPS and TBT measures). We merge at the six-digit level of the tariff line the technical measures data with trade data. Our import data are from the United Nations International Trade Statistics Database (COMTRADE). Our sample includes 7 subsectors (HS2). We calculate the coverage ratio, which is the ratio of affected imports over potentially affected imports (Disdier et al., 2008). The above authors define potentially affected imports as the value of global imports at the six-digit HS level, which groups tariff lines on which measures have been taken, and affected imports as the value of global imports (in affected products) by countries adopting these measures.

The results are reported in [Table A.2](#) and [Table A.3](#) of the Appendix. These tables show for each subsector the affected imports, potentially affected imports and coverage ratio. With respect to SPS measures, subsectors HS44 and HS46 are the most affected with a larger share of technical regulations. Subsectors HS48, HS49 and HS94 are the least affected. Similarly, for TBT measures, subsectors HS44, HS47 and HS94 are the most affected. Subsector HS49 is the least affected by these TBT measures. It should be noted that subsector HS44 is equally affected by SPS and TBT measures, with a slight predominance found for TBT measures. The wood furniture and furniture parts subsector (HS94) is largely more affected by TBT measures. In addition, SPS measures are more widely used in subsectors upstream of the whole sector, such as raw wood, log, particle and TBT measures of the subsectors that constitute the paper industry. In fact, raw and minimally processed products present a greater risk of

containing harmful organisms that can pose risks to plant preservation and human and animal health. Products of second transformation, including paper, cardboard, and furniture, are more governed by rules of safety and quality.

1.4 Model

The impact of SPS and TBT measures in the forest-wood-paper sector is estimated using a gravity model. This model is used to predict the volume of trade between countries based on the sizes of the countries and the distances between them. Studies by Anderson (1979), Anderson and Van Wincoop (2003), and Jeffrey H Bergstrand (1985) have provided theoretical justifications for this model. Anderson (1979) bases his approach on Armington's hypothesis of product differentiation by origin. Jeffrey H Bergstrand (1985) shows that the gravity model can be applied to the monopolistic competition model introduced by (Krugman, 1980) in which consumers have a preference for variety.

Following Arita et al. (2015) and Fassarella et al. (2011), our theoretical foundation is based on the constant elasticity of substitution (CES) model developed by Anderson and Van Wincoop (2003, 2004). According to Anderson and Van Wincoop (2004), exports from country i to country j related to sector k are expressed as follows:

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y^k} \left(\frac{t_{ij}^k}{P_j^k \Pi_i^k} \right)^{1-\sigma_k} \quad (1.1)$$

where X_{ij}^k represents exports from country i to country j of products k , Y_i^k is the production of country i , and Y^k is global production in sector k . E_j^k represents the expenditure of country j on k products, t_{ij}^k is the trade cost, and σ_k is the elasticity of substitution. P_j^k and Π_i^k represent price indexes that capture the multilateral resistance term. The term "multilateral resistance" highlights the importance of trade costs not only between the two countries (importer and exporter) but also with other partners. This term is unobservable and can be controlled either by proxies known as "remoteness indexes" such as GDP-weighted distance averages or by country, sector and time fixed effects. These fixed effects control specific characteristics that may affect trade. Our estimated equation is as follows:

$$X_{ijt}^k = \exp[\alpha_i + \alpha_j + \alpha_k + \alpha_t + \beta_1(\text{SPS/TBT})_{ij(t-1)}^k + \beta_2 \ln(d_{ij}) + \beta_3 \ln(1 + \text{tariff}_{ijt}^k) + \beta_4 \text{contig}_{ij} + \beta_5 \text{comlang}_{ij} + \beta_6 \text{colony}_{ij} + \beta_7 \text{RTA}_{ijt} + \beta_8 \ln(\text{GDP}_{it} \times \text{GDP}_{jt}) + \varepsilon_{ijt}^k] \quad (1.2)$$

where X_{ijt}^k denotes imports of country j from country i for products k (six-digit level of the HS) and at time t (year), $(\text{SPS/TBT})_{ij(t-1)}^k$ is the regulatory intensity level, which is the number of measures (technical regulations or conformity assessment procedures) that affect product k imposed by country j on country i . We consider both unilaterally and bilaterally imposed measures. We use the lag of this measure (one year before t). NTMs can be influenced by imports to the extent that an importing country may decide to impose more technical measures to restrict exports from a specific exporter or sector. This endogeneity problem (reverse causality) can be partially solved by using the lag of our variable of interest.

7

Control variables include d_{ij} the geographic distance between capitals; dummy variables that indicate whether countries are contiguous (contig_{ij}), share an official language (comlang_{ij}), have colonial ties (colony_{ij}) and the log of the product of GDPs of importer j and exporter i ($\ln(\text{GDP}_{it} \times \text{GDP}_{jt})$)⁸. These control data come from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database. Control variable RTA_{ijt} is a binary variable that indicates whether countries i and j have signed a regional trade agreement and is obtained from Egger and Larch (2008)⁹. We include in our specification the bilateral applied tariff on k products (six-digit level of the HS) (tariff_{ijt}^k) to distinguish its impact from that SPS and TBT measures. Tariff data are derived from World Integrated Trade Solution (WITS) data provided by the Integrated Database (IDB-WTO) and TRAINS¹⁰. $\alpha_i + \alpha_j + \alpha_k + \alpha_t$ are exporter, importer, product and time fixed effects. Bao and Qiu (2012) and Peci and Sanjuán (2020) also use a set of fixed effects (importer, exporter, and time) without interacting them to account for multilateral resistance. In our specification, we do not interact the importer (exporter) dummies with the product and time dummies. Techni-

⁷We lose one year of data given the lagged structure of our regulatory intensity variable.

⁸The bilateral GDP product reduces multicollinearity with fixed effects and problems of identifying income elasticities. (Peci and Sanjuán, 2020; Silva and Tenreyro, 2006)

⁹These data are available at <https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html>

¹⁰These data are calculated as simple tariff line averages and incorporate ad valorem equivalents of nonad valorem rates

cal measures are mainly measures applied without targeting a particular country, except in exceptional cases. Although we consider measures applied bilaterally in our database, technical measures are mainly unilateral. Thus, the inclusion of these fixed effects would absorb all the variation within these technical measures needed to estimate the effect and could lead to biased estimates. These fixed effects control the heterogeneity of countries (size effects) and the factors that have an impact on trade. ε_{ijt}^k is an error term.

We use the Poisson pseudo maximum likelihood (PPML) estimator recommended by Silva and Tenreyro (2006) to take into account zero trade flows between countries and the selection bias of the sample and to correct for biases that may result from heteroscedasticity problems. Another approach is to use the Heckman selection model (Heckman, 1979). In contrast to the PPML method, the Heckman model allows more focus on the selection issue. However, as pointed out by (Ferro et al., 2015; Fiankor et al., 2020a), this model suffers from limitations such as nonrobust results with respect to heteroskedastic errors and misspecification and incidental parameter problems of the first-stage probit equation in panel data configurations. Therefore, we prefer the PPML method.

1.5 Results

1.5.1 Baseline Results

The baseline results are shown in Table 1.1. The set of these estimates includes all control variables, such as the log of distance, the log of (1+tariff), contiguity, common language, colony ties, regional trade agreements (RTAs) and the log of the GDP of importers and exporters. In general, these variables have the expected signs and are in line with the literature.

We observe that distance and bilateral tariffs have a negative impact on trade. Contiguity and economic size (GDP) favor trade. We find that the variables for a common language and colony ties have a positive sign but are not significant. The RTA variable has the expected sign but is not significant. For SPS and TBT measures, the estimated coefficients on SPS and TBT conformity assessment procedures are positive and significant. The estimated coefficient on TBT technical regulations is positive and significant and that on SPS technical regulations is negative and insignificant. These results suggest that trade flows in-

Table 1.1: The impact of SPS and TBT measures on Trade in the Forest-Wood-Paper sector: Base-line results

Dependent variable: imports	PPML Estimates			
	(1)	(2)	(3)	(4)
SPS_Technical Regulations	-0.0236 (0.0693)			
TBT_Technical Regulations		0.144*** (0.0267)		
SPS_Conformity Assessments			0.0957*** (0.0371)	
TBT_Conformity Assessments				0.195*** (0.0195)
Indist	-0.390*** (0.0424)	-0.389*** (0.0430)	-0.388*** (0.0425)	-0.398*** (0.0415)
ln(1+tariff)	-0.280*** (0.0363)	-0.265*** (0.0358)	-0.270*** (0.0373)	-0.190*** (0.0372)
Contiguity	0.768*** (0.107)	0.770*** (0.107)	0.771*** (0.107)	0.763*** (0.103)
Common language	0.0243 (0.0905)	0.0280 (0.0904)	0.0274 (0.0904)	0.0320 (0.0901)
Colony ties	0.104 (0.111)	0.108 (0.111)	0.104 (0.111)	0.105 (0.108)
RTA	0.0199 (0.0901)	0.0331 (0.0892)	0.0263 (0.0901)	0.0595 (0.0892)
GDP	0.0402*** (0.00644)	0.0403*** (0.00643)	0.0406*** (0.00645)	0.0434*** (0.00626)
Nbr of Observations	530,549	530,549	530,549	530,549

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer, exporter, product and time fixed effects. The Stata package `ppmlhdfc` is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

crease in the presence of SPS and TBT conformity assessment procedures and TBT technical regulations. The positive impact of TBT and SPS measures on trade has also been demonstrated in the literature on other sectors. For example, Bao and Qiu (2012) find a positive impact of TBT measures on the value of trade flows. The positive impact of these measures

on trade in the forest-wood-paper sector that we find can be explained by the fact that these measures provide consumers with information on the quality and safety of wood products, which will help increase their demand. This is even more apparent given that raw wood and wood products can contain harmful organisms. Consumers, especially of products upstream of the sector such as logs, sawn timber, and wood panels will be more vigilant and will be interested in products with quality characteristics; meeting safety, sanitary and phytosanitary standards and coming from sustainably managed forests. Conformity assessment procedures, although costly for exporters, and TBT technical regulations that focus more on the quality and safety characteristics of products inform consumers that products comply with safety and quality regulations and are safe. This increases their demand for these compliant products, thereby offsetting the costs associated with product adaptation.

1.5.2 Robustness

In this section, we perform robustness analyses of our results. First, we include country pair fixed effects in our model. As emphasized in the literature (P. H. Egger and Nigai, 2015; Yotov et al., 2016), these fixed effects are used to control for the endogeneity of trade policies due to reverse causality bias, which is already accounted for by the lag of our variables of interest and the bias of omitted variables such as trade costs. The results are reported in [Table 1.2](#).

Table 1.2: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector: Robustness

Dependent variable: imports	PPML Estimates			
	(1)	(2)	(3)	(4)
SPS_Technical Regulations	-0.0154 (0.0743)			
TBT_Technical Regulations		0.139*** (0.0263)		
SPS_conformity assessments			0.0964*** (0.0374)	
TBT_conformity assessments				0.197*** (0.0205)
ln(1+tariff)	-0.230*** (0.0395)	-0.214*** (0.0392)	-0.221*** (0.0401)	-0.121*** (0.0375)
RTA	-0.00811 (0.0500)	-0.0124 (0.0503)	-0.0115 (0.0496)	-0.0802 (0.0576)
GDP	0.0127*** (0.00189)	0.0132*** (0.00190)	0.0129*** (0.00187)	0.0134*** (0.00183)
Nbr of Observations	529,528	529,528	529,528	529,528

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-exporter, product and time fixed effects. These country pair fixed effects will absorb all bilateral time-invariant variables. We include only control variables in our estimates: RTA, GDP and log of (1+tariff). The Stata package `ppmlhdfc` is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

We note that bilateral tariffs, as in our baseline results, decrease trade. The GDP variable is significant with a positive sign. The RTA variable is not significant but has a negative sign, as in the study of Peci and Sanjuán (2020). The estimated coefficients on SPS and TBT conformity assessment procedures and on TBT technical regulations are positive and significant. The coefficient for SPS technical regulations is negative and insignificant. In general, the results of this analysis are consistent with our baseline results, and the magnitudes of the coefficients are slightly lower than those reported in Table 1.1.

Furthermore, we do not include importer- and exporter-product-time fixed effects in our

estimates because SPS and TBT measures do not target specific partners but affect all partners. However, we consider both bilaterally and unilaterally imposed measures in our estimates. These measures are mostly imposed unilaterally. Therefore, these fixed effects, especially importer-product-time fixed effects, would absorb all variation needed to estimate the effect. Heid et al. (2017) and Yotov et al. (2016) point out that estimates of structural gravity should be made using data that include international and intranational trade flows (domestic trade flows). This ensures consistency with gravity theory and makes it possible to identify the effects of bilateral trade policies in a theoretically coherent manner. Intranational trade flows are calculated as the difference between gross production data value and total exports. In our analysis, we cannot include these data in our estimates due to the unavailability of these data for the majority of countries and for all products at the six-digit level of the HS. In addition, the aggregate data available for some countries on the production of wood and wood products do not fully correspond to the classification of products considered in our study, and their use could lead to inconsistent and biased results.¹¹ Another alternative approach is to estimate the impact of these measures in two steps. We apply the same approach as Kinzius et al. (2019). This two-step procedure proceeds as follows: In the first stage, using the PPML estimator, we estimate our model with importer-product-time, exporter-product-time and importer-exporter fixed effects and the set of control variables: RTA, the log of (1+tariff) without our variable of interest (SPS and TBT measures). In the second stage, using the OLS estimator, the importer-product-time fixed effects predicted in the first stage are regressed on the SPS and TBT measures. The aim is to analyze the impact of these technical measures on the importer's market access. In this second estimate, we include importer-time fixed effects. Kinzius et al. (2019) also point out a disadvantage of using the two-step procedure. Based on the study by Fally (2015), the authors note that "the estimated importer product (time) can be represented as a function of the power transformation of the corresponding inward multilateral resistance and national expenditures if a gravity equation is estimated using the PPML. Thus, in combination, the importer-product (time) inward multilateral resistance and importer-product (time) expenditure will explain 100 percent of the importer-product (time) fixed effects in the second step OLS estimate." We still use this method as part of a sensitivity analysis to confirm the robustness of our results.

¹¹We turned to the new International Trade and Production Database for estimation (ITPD-E), which provides information on domestic and international trade flows. However, the amount of missing domestic flow data for the countries and sectors included in our sample over the period considered is too large to use these data.

The results of this two-step procedure are presented [Table 1.3](#).

Table 1.3: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector: Robustness

	First Stage (PPML)		Second stage (OLS)		
	(1)	(1)	(2)	(3)	(4)
ln(1+tariff)	-0.0655** (0.0259)				
RTA	0.0232 (0.0269)				
SPS_Technical Regulations		-0.0369 (0.0292)			
TBT_Technical Regulations			0.135*** (0.0223)		
SPS_Conformity Assessments				0.0103 (0.0351)	
TBT_Conformity Assessments					0.123*** (0.0350)
Nbr of Observations	509,468	509,468	509,468	509,468	509,468

Note: Robust standard errors in parentheses clustered by country-pair-product (column(1)) and importer-product (column(2)). *** p<0.01, ** p<0.05, * p<0.1. Column (1) includes exporter-product-time, importer-product-time, importer-exporter fixed effects. Column (2) includes importer-time fixed effects. The GDP variable is not included in the first stage because it is collinear with the fixed effects. We use command PPMLHDFE (Correia et al., 2019) and REGHDFE (Correia, 2019) in stata. Dependent variable: Imports (column (1)) and importer-product-time fixed effects ((column(2)). we are cautious about including fixed effects in the second stage because, as Ferrantino (2006) pointed out, fixed effects can obscure the information about NTMs that the analysis attempts to infer. Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

In the first stage, we observe that bilateral tariffs have a negative impact on trade. The coefficient on the RTA variable is positive and insignificant. In the second stage, we find that the estimated coefficients on technical regulations and SPS conformity assessment procedures have the same sign as in our baseline results but are not significant. Those on TBT measures are positive and significant, but of a smaller magnitude. The low magnitude of the coefficients and the non-significance of the coefficient for SPS measures which could be explained by the drawback pointed out by Kinzius et al. (2019). On average, TBT measures

promote importer-product market access. In view of these results, we can attest that these robustness analyses confirm our results presented in [Table 1.1](#). In the rest of our analysis, we include in the estimations the country-pair fixed effects instead of the bilateral invariant variables.

1.5.3 Heterogeneity

In this section, we first test the heterogeneous effects of SPS and TBT measures on trade as a function of countries' levels of development. Then we determine their effects in each subsector of the forest-wood-paper sector. As noted in the literature, countries at different levels of development may have different SPS and TBT measures, and their trade may be affected differently. To test this hypothesis, we apply the same methodology as Bao and Qiu (2012). We create an interaction variable between our variable of interest and a dummy variable that takes a value of 1 when the importing country is a developed country and 0 otherwise. We include this interaction variable in our model, and the coefficient of this variable enables us to test whether the effects of SPS and TBT measures imposed by developed and developing countries are significantly different. Similarly, we divide all exporting countries into developed and developing countries and estimate our model with the interaction variable for each exporter group.

The results for developed exporting countries are presented in columns (1)-(4) of [Table 1.4](#), and those for developing exporting countries are presented in columns (5)-(8) of [Table 1.4](#).¹² First, when we focus on developed exporting countries, we find that SPS and TBT conformity assessment procedures and TBT technical regulations are trade enhancing. The estimated coefficient of SPS technical regulations is not significant. The impact of measures imposed by developed and developing countries is similar (interaction terms are not statistically significant in columns (1)-(4))

¹²The classification into developed and developing countries is based on the UNCTAD country classification. The dummy variable is omitted in our estimations because it is collinear with the fixed effects. We estimate our model with the interaction variable on all exporters and without the interaction variable for each group of exporters. The results are presented in [Table A.5](#) and [Table A.6](#) of the Appendix. The results presented in [Table A.6](#) show that SPS and TBT conformity assessment procedures and TBT technical regulations increase trade flows for all exporters. However, the positive impact of TBT conformity assessment procedures is less significant when these measures are imposed by developed countries, and SPS conformity assessment procedures imposed by developed countries hinder trade. We also find from [Table A.5](#) that SPS and TBT conformity assessment procedures and TBT technical regulations promote trade (as in our baseline result) for both developed and developing country exporters. SPS technical regulations reduce exports from developing countries. The trade-enhancing effect is weaker for developing country exporters.

For exporters in developing countries, the impact of measures imposed by developed and developing countries on trade varies. SPS and TBT technical regulations imposed by developing countries have no significant impact on trade. The estimated coefficient on SPS technical regulations is positive and insignificant (column (5)) and that on TBT technical regulations is negative and insignificant (column (6)). In contrast, the interaction terms are significant and are negative in column (5) and positive in column (6). On the one hand, this result suggests that SPS technical regulations imposed by developed countries tend to inhibit trade with exporters in developing countries. On the other hand, TBT technical regulations imposed by developed countries are more conducive to trade. In addition, conformity assessment procedures imposed by developing countries promote trade (columns (7)-(8)). However, these measures tend to be trade restrictive when imposed by developed countries. The coefficients of the interaction terms are negative and significant.

In summary, it should be noted that when we do not distinguish between the level of development of importing countries (which impose the technical measures), the trade-enhancing effect of SPS and TBT conformity assessment procedures and TBT technical regulations is weaker for exporters in developing countries than for those in developed countries ([Table A.5](#)). When we distinguish the levels of development of countries implementing these technical measures, we find that SPS and TBT conformity assessment procedures and TBT technical regulations have the effect of increasing trade with developed country exporters regardless of the development levels of the countries imposing them.

Table 1.4: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector by country groups

Dependent variable: imports	PPML Estimates							
	Developed	Developed	Developed	Developed	Developing	Developing	Developing	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_Technical Regulations	0.0548 (0.0580)				0.0855 (0.0525)			
TBT_Technical Regulations		0.166*** (0.0465)				-0.00526 (0.0373)		
SPS_Conformity Assessments			0.123** (0.0488)				0.105** (0.0461)	
TBT_Conformity Assessments				0.197*** (0.0250)				0.200*** (0.0366)
SPS_Technical Regulations*imp_devped	-0.0201 (0.0792)				-0.347*** (0.0858)			
TBT_Technical Regulations*imp_devped		-0.0527 (0.0606)				0.183*** (0.0613)		
SPS_Conformity Assessments*imp_devped			-0.0669 (0.0779)				-0.851*** (0.152)	
TBT_Conformity Assessments*imp_devped				0.0203 (0.0791)				-0.235*** (0.0746)
ln(1+tariff)	-0.435*** (0.0510)	-0.406*** (0.0508)	-0.416*** (0.0507)	-0.238*** (0.0473)	-0.0654 (0.0472)	-0.0629 (0.0485)	-0.0642 (0.0492)	-0.0240 (0.0479)
RTA	0.00521 (0.0865)	-0.00654 (0.0884)	0.00751 (0.0868)	0.0410 (0.0839)	-0.0472 (0.0716)	-0.0522 (0.0710)	-0.0149 (0.0751)	-0.0325 (0.0762)
GDP	0.0112*** (0.00212)	0.0118*** (0.00217)	0.0114*** (0.00212)	0.0131*** (0.00221)	0.00798** (0.00351)	0.00696* (0.00388)	0.00803** (0.00339)	0.00757** (0.00374)
Nbr of Observations	266,843	266,843	266,843	266,843	262,685	262,685	262,685	262,685

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-exporter, product and time fixed effects. Columns (1)-(4): Exporters-developed, Columns (5)-(8): Exporters-developing. The Stata package ppmlhdfc is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates.

Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

In contrast, SPS and TBT technical regulations imposed by developing countries do not have a significant impact on imports from developing countries, while SPS and TBT conformity assessment procedures contribute to increasing them. SPS and TBT conformity assessment procedures and SPS technical regulations imposed by developed countries tend to restrict trade with developing country exporters, while TBT technical regulations tend to enhance trade. In other words, the effect of these measures on trade is more favorable to exporters in developed countries. This may be because developing countries have limited technical capacity and resources to comply with the measures imposed, which results in significant costs. In addition, developing countries' technical measures may be weaker than those of developed countries, which would require the mobilization of greater resources for compliance. For example, Bao and Qiu (2012) have pointed out that TBTs increase the costs of exporters in developing countries more than those in developed countries. The authors also point out that technical standards in developing countries are lower than those in developed countries. Thus, the cost of product compliance is higher for these countries.

To highlight differences or similarities in terms of technical measures imposed by developed and developing countries to support our results, we calculate bilateral indicators. We rely on the studies of (Cadot et al., 2015, 2018; Sanjuán López et al., 2018; UNCTAD, 2017). The indicators include the regulatory intensity gap (RIG), similarity index (SI) and regulatory overlap (RO). The regulatory intensity gap is the difference in regulatory intensity (the number of measures applied) between the importer and exporter. The similarity index measures the proportion of technical measures shared by the importer and exporter. Regulatory overlap measures the proportion of technical measures applied by the importer that are also applied by the exporter. Sanjuán López et al. (2018) emphasize that the regulatory overlap and similarity index are different in that the regulatory overlap determines the types of measures imposed by the importer and then whether those measures are applied by the exporter.¹³

¹³We apply the same calculation methods as (Sanjuán López et al., 2018) with a few differences. For example, we distinguish between SPS and TBT technical regulations and conformity assessment procedures. The regulatory intensity gap is calculated as $RIG_{ij}^k = \frac{1}{M} \sum_{m=1}^M RI_j^{k,m} - RI_i^{k,m}$. $RI_j^{k,m}$ is the number of technical measures applied by importer j for each product k, $RI_i^{k,m}$ is the number of technical measures applied by exporter i for each product k, and M is the total number of types of technical measures of the different SPS and TBT categories (technical regulations and conformity assessment procedures). If RIG is negative, exporter i imposes more measures than importer j on average in all categories and inversely.

The similarity index is calculated as follows: $SI_{ij}^k = 1 - \frac{1}{M} \sum_{m=1}^M |d_j^{k,m} - id_i^{k,m}|$. $d_j^{k,m}$ is a dummy variable that takes a value of 1 when importer j applies at least one technical measure to product k and 0 otherwise. $id_i^{k,m}$ captures the presence of technical measures in product k applied by exporter i. Vertical lines signify the absolute value. If the regulatory structure between the two countries is similar, the SI indicator is close to 1 and is

These indicators are averaged over the six-digit HS products, the years considered, and the importers and exporters in our sample. These indicators will highlight regulatory differences or similarities between developed and developing importing countries and developed and developing exporting countries. For exporters, we consider the technical measures related to imports adopted in these countries. Given WTO principles of nondiscrimination between domestic and foreign products, most measures applied as import-related non-tariff measures (NTMs) should also be applied domestically for domestic producers (UNCTAD, 2017). Thus, it can be assumed that if importing and exporting countries have similar regulatory models or structures, it will be easier for the exporter to comply with measures imposed by the importing countries to which it exports.

The results are reported in Table 1.5 and Table 1.6. In Table 1.5, columns (1)-(4) show the results for developed importing and exporting countries, and columns (5)-(8) show the results for developed importing countries and developing exporting countries. In Table 1.6, columns (1)-(4) show the results for developing importing countries and developed exporting countries, and columns (5)-(8) show the results for developing importing and exporting countries.

close to 0 if the structure is different.

The regulatory overlap is calculated as $RO_{ij}^k = \frac{\sum_{m=1}^M d_j^{k,m} \times id_i^{k,m}}{\sum_{m=1}^M d_j^{k,m}}$. The sum of the numerator is the number of technical measures that the importer and exporter share in the different SPS and TBT categories. The denominator is the number of technical measures applied by importer j for product k. The regulatory overlap is equal to 0 when there is no overlap and 1 when there is regulatory overlap. the RO value is replaced with 1 when no nontariff measures are imposed by the importer (Sanjuán López et al., 2018; UNCTAD, 2017).

Table 1.5: Bilateral Indicators by Country groups (importers-developed)

	Developed	Developed	Developed	Developed	Developing	Developing	Developing	Developing
Regulatory Intensity Gap								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	0.022				0.190			
TBT_ Technical Regulations		0.100				0.679		
SPS_conformity assessments			0.049				-0.146	
TBT_conformity assessments				0.076				0.454
Similarity Index								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	97%				98%			
TBT_ Technical Regulations		94%				94%		
SPS_conformity assessments			98%				97%	
TBT_conformity assessments				93%				93%
Regulatory Overlap								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	76%				72%			
TBT_ Technical Regulations		55%				53%		
SPS_conformity assessments			92%				94%	
TBT_conformity assessments				59%				51%

Columns (1)-(4): Developed exporting countries, columns (5)-(8) Developing exporting countries.

Table 1.6: Bilateral Indicators by Country groups (importers-developing)

	Developed	Developed	Developed	Developed	Developing	Developing	Developing	Developing
Regulatory Intensity Gap								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	-0.209				0.020			
TBT_ Technical Regulations		-0.565				0.051		
SPS_conformity assessments			0.157				0.0100	
TBT_conformity assessments				-0.635				-0.032
Similarity Index								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	98%				98%			
TBT_ Technical Regulations		93%				97%		
SPS_conformity assessments			97%				96%	
TBT_conformity assessments				93%				96%
Regulatory Overlap								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	90%				89%			
TBT_ Technical Regulations		91%				91%		
SPS_conformity assessments			90%				90%	
TBT_conformity assessments				90%				90%

Columns (1)-(4): Developed exporting countries, columns (5)-(8) Developing exporting countries.

Regarding the regulatory intensity gap, when we focus on developed exporting countries, we find that the RIG value is positive and low for all categories of SPS and TBT technical measures in [Table 1.5](#). In other words, on average, developed importing countries apply more measures than developed exporting countries, but the gap remains small. In [Table 1.6](#), the RIG value is negative; on average, developing importing countries apply fewer measures than developed exporting countries except for SPS conformity assessment procedures. The gap in regulatory intensity is larger between these two types of partners.

For developing exporting and developed importing countries, the regulatory intensity gap is on average larger and positive, except for SPS conformity assessment procedures ([Table 1.5](#)). For the latter, developed importing countries on average adopt fewer measures than developing exporting countries on their imports. For developing exporting and importing countries, the regulatory intensity gap is on average very small and positive, except for TBT conformity assessment procedures ([Table 1.6](#)). These results show that the regulatory intensity gap is larger between developed importing and developing exporting countries and between developing importing and developed exporting countries. On average, the regulatory intensity of developing countries is lower than that of developed countries. This may partly explain our results; on average, developing importing and developing exporting countries have similar regulatory intensities, while developed countries have higher regulatory intensities. The cost of adapting products to the technical measures imposed by developed countries will be higher and will require a significant mobilization of financial and technical resources for developing countries with limited means to comply. Thus, these developed country measures will have a more trade-restrictive impact on developing country exporters than those of developing countries, which will be more favorable. However, regulatory intensity is only one factor, among others, that can explain our results. As we can see, for SPS conformity assessment procedures, developed importing countries adopt fewer measures on average than developing exporting countries, but these are not very favorable to trade between these types of partners. Thus, we believe that this may be explained by other factors, such as regulatory characteristics and access to technical and financial means to comply.

The results of the similarity index and regulatory overlap are expressed as percentages (multiplied by 100). The similarity index highlights the regulatory patterns between importers and exporters. We find that, on average, regulatory patterns are similar between importers and exporters. The SI value is close to 100 percent for all categories of technical measures.

Regulatory overlap highlights the proportion of measures applied by importers that are also applied by exporters. The measure expresses, among other things, the share of the importer's NTMs that the exporter already deals with at the domestic level. It can therefore be assumed that the greater the share of the importer's measures also applied by the exporter is, the easier it will be for the exporter to comply with the importer's measures. We find that for SPS and TBT technical regulations and TBT conformity assessment procedures, regulatory overlap is on average slightly higher between developed importing and exporting countries. For SPS conformity assessment procedures, regulatory overlap is slightly higher between developed importing countries and developing exporting countries ([Table 1.5](#)). Regulatory overlap is also high between developing importing countries and developed and developing exporting countries. Understandably, the coincidence of measures applied by developing importing countries that are also applied by developed exporting countries is important. However, the reverse (developed importing countries/developing exporting countries) is not obvious, as developing countries apply international standards, while developed countries with more technical resources can, in addition to international standards, apply more restrictive measures on the basis of risk justification. We see an average overlap of over 50 percent.

Overall, we find that on average, the difference in regulatory intensity is greater between developed and developing countries. There is little difference in the similarities of regulatory models between them. Regulatory overlap is slightly lower between developed importing countries and developing exporting countries. These results suggest that on average, it will take more effort (technical and financial) for developing country exporters than for developed country exporters to comply with the technical standards imposed by developed countries, which have higher regulatory intensity than they do. However, it should be noted that these indicators are approximations of similarities or differences in regulatory structures or patterns. For example, regulatory overlap refers to measures applied by the importer but also by the exporter. However, in reality, these measures applied by partners may be the same, but their application may be completely different from one country to another. Since the regulatory process is complex and involves a variety of factors that are not easily understood, further analysis, including a survey, will be useful in this context.

Now, we determine what effects the SPS and TBT measures have on trade in each subsector of the forest-wood-paper sector. To do this, we estimate our equation with country-pair fixed effects for each subsector at the HS2 level separately. This has the advantage of allowing

the estimation of the coefficients of all other explanatory variables that differ across subsectors. The results are presented in [Table 1.7](#). For the HS44 subsector, we find a positive effect of SPS and TBT conformity assessment procedures on trade. For HS45 and HS94 subsectors, a negative effect of SPS measures (technical regulations and conformity assessment procedures) on trade. For subsector HS46, SPS conformity assessment procedures have a negative effect on trade, while SPS technical regulations and TBT measures have a positive effect on trade. For HS47 and HS49 subsectors, SPS and TBT measures (technical regulations and conformity assessment procedures) have a positive effect on trade. TBT technical regulations have a positive effect and SPS conformity assessment procedures a negative effect on trade in the HS48 subsector.

Table 1.7: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector by subsector, HS2

Dependent variable: imports	PPML Estimates			
	(1)	(2)	(3)	(4)
	SPS_Technical Reg- ulations	TBT_Technical Regulations	SPS_Conformity Assessments	TBT_Conformity Assess- ments
HS44: "Wood and articles of wood; wood charcoal"	0.0249 (0.0785)	0.00145 (0.0617)	0.125** (0.0546)	0.268*** (0.0417)
HS45: "Cork and articles of cork"	-0.446** (0.205)	-0.319 (0.293)	-0.449* (0.249)	0.0330 (0.0718)
HS46: "Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork"	0.213* (0.116)	0.334* (0.184)	-0.0523* (0.0285)	0.208* (0.109)
HS47: "Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard"	0.982** (0.399)	0.301*** (0.103)	0.484** (0.196)	0.210*** (0.0599)
HS48: "Paper and paperboard; articles of paper pulp, of paper or of paperboard"	-0.0136 (0.0635)	0.0831*** (0.0313)	-0.147** (0.0695)	0.0786 (0.0483)
HS49: "Printed books, newspapers, pictures and other products of the printing industry; manuscripts, type-scripts and plans"	0.843*** (0.219)	0.153*** (0.0390)	0.426*** (0.111)	0.230** (0.106)
HS94: "Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated name-plates and the like; prefabricated buildings"	-0.132*** (0.0384)	0.0292 (0.0577)	-0.0454*** (0.0126)	-0.155 (0.0971)

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-exporter, product and time fixed effects. All estimates include the explanatory variables: RTA, bilateral tariffs and GDP. For simplicity, we report only the coefficients on the SPS and TBT measures. Details of the estimates are available upon request. The Stata package `ppmlhdf` is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

An interesting result is that SPS and TBT measures have a different effect depending on the subsector considered. In sum, TBT measures are more trade-enhancing, especially in the paper industry.

1.6 Conclusion

In this paper, we analyze the impact of the presence of SPS and TBT measures on trade in the forest-wood-paper sector. Using a gravity model, we show that in general, SPS and TBT conformity assessment procedures and TBT technical regulations increase trade flows. These results suggest that these measures provide information to consumers about product quality and compliance with standards, thereby increasing consumer demand for these products. The increased demand will therefore offset the fixed costs of product adaptation, resulting in a positive impact. In addition, we find that the trade-enhancing effect of these measures is smaller for developing country exporters. SPS technical regulations reduce imports from developing countries. We also find that the positive impact of these measures on imports from developed countries is not different regardless of the level of development of the countries imposing them. In contrast, SPS and TBT conformity assessment procedures and SPS technical regulations imposed by developed countries tend to restrict trade with developing country exporters, while TBT technical regulations tend to increase it. SPS and TBT technical regulations imposed by developing countries do not have a significant impact on imports from developing countries, while SPS and TBT conformity assessment procedures contribute to increasing them. To explain these heterogeneous effects, we calculate bilateral indicators of differences and similarities in the regulatory patterns (import measures) of developed and developing countries. Our main finding is that, on average, the regulatory intensity gap is larger between developed and developing countries. The regulatory overlap between developed importing countries and developing exporting countries remains somewhat low. This finding suggests that developing countries need more technical and financial resources to comply with developed country technical standards that are more important than their own. Furthermore, when we analyze the effects of SPS and TBT measures for each subsector at the HS2 level, we find that these measures have a different effect depending on the subsector considered. The positive effect of TBT measures on trade is most pronounced in the paper industry.

Future research could seek to further explain these heterogeneous effects that may result from the regulatory process adopted by countries. Surveys will be of great value in this context and may identify qualitative factors that are difficult to measure. We recognize that our study has limitations, including its use of the UNCTAD Trains database, which lacks time

series that could allow for more in-depth analysis with greater temporal variation that would contribute to a better understanding of the effects of these trade policies in the forest-wood-paper sector.

Sanitary and Phytosanitary Measures and Trade: Evidence from the Wood Sector

2.1 Introduction

In recent decades, as tariff barriers have been reduced, trade has expanded and non-tariff measures (NTMs) used to regulate trade have increased. These include sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT). SPS and TBT measures are measures designed to achieve legitimate objectives such as the protection, health and safety of humans and animals and the preservation of plants or the environment. SPS measures focus primarily on the health and protection of people and animals, and the preservation of plants from disease and pests. TBT measures cover measures not covered by SPS measures, such as measures related to human safety and environmental protection. However, the motives behind the adoption of these measures are not always explicit and legitimate (Swinnen, 2016). Indeed, these measures can be used to favour domestic producers at the expense of foreign producers. Although these measures are governed by the World Trade Organization (WTO) agreements, which stipulate the rules that member states must follow in developing and applying these measures, governments may adopt more restrictive measures than those provided for in these agreements. This has led some authors to question the impact of these measures on international trade in the literature. The effects of NTMs on trade are theoretically ambiguous; analysis of these effects remains an important empirical question (Fiankor et al., 2021). Studies show that SPS or TBT measures have a positive impact on the value of trade ((Bao and Qiu, 2012; Crivelli and Gröschl, 2016)). Anders and Caswell (2009), Disdier

et al. (2008), and Grant et al. (2015) show, on the contrary, a negative effect of NTMs. NTMs increase trade costs because they promote the costs of adapting products and production processes to these measures, which justifies their negative impact on trade. However, these measures have the advantage of providing information on product quality and safety to consumers, which increases their confidence and demand for these products, which will offset the costs of adaptation and thus the positive effect (Crivelli and Gröschl, 2016).

Moreover, although the duration of trade relations is one of the most important components of trade performance (Bao and W.-C. Chen, 2013), very few studies have examined the impact of NTMs on this duration. Duration is defined as the period during which trade between the partners is uninterrupted. Bao and W.-C. Chen (2013) show that TBTs have a positive impact on the duration of existing trade relationships. Peterson et al. (2018) show that the impact of phytosanitary treatments on trade duration is persistent over time. These varied effects highlight the complexity of these measures, which are difficult to characterize.

In this study, we analyze the effect of SPS measures on trade in wood and wood products over the period 2000-2019. These measures represent a real issue in the international trade. Indeed, trees provide a natural habitat for various organisms (Allen et al., 2017). Wood from living or dead trees can be infested with pests (FAO, 2019b). Wood packaging materials, such as pallets, are considered one of the high-risk pathways for the introduction of pests, insects. (Haack et al., 2014). These organisms can spread from one country to another through international trade and can pose risks to plant health and the environment within countries. As Leal et al. (2010) point out, international trade in wood and wood products has greatly increased the potential for the spread of invasive alien pests and the risk of negative consequences for recipient countries. In addition to ecological effects, the spread of these species has economic effects for the affected countries, such as reduced value of timber and non-timber products, which may be due to loss of volume from tree death. The costs associated with controlling an established pest, including control or eradication efforts, can be considerable (Leal et al., 2010). Thus, faced with these risks, the implementation of SPS measures aims to prevent the spread of pests and to protect the health of humans and animals and preserve plants. However, these measures can be protectionist and restrict the trade of wood and wood products.

The objective of our analysis is to determine the effect on trade of SPS measures con-

sidered as trade barriers. We determine the effect of these measures on the value of trade and on the duration of trade. We use the database of specific trade concerns (STCs) raised by countries affected by SPS measures in the WTO SPS Committee. These data allow us to highlight the restrictive nature of these measures. Indeed, specific trade concerns can be considered *de facto* trade restrictive measures, as they are raised by countries in the WTO because they represent a barrier to trade (Curzi et al., 2020). The advantage of using specific trade concerns is that they can highlight the restrictive nature of these measures, determine when these measures are considered trade barriers, and, most importantly, overcome the limitations of SPS reporting data.

Our contribution to this literature is twofold. First, to our knowledge, we are the first to use the STC database to analyze the effect of restrictive SPS measures on trade in wood and wood products. We estimate the effects of these restrictive measures on the value of trade with a gravity model. The main studies in the literature focus on the agri-food sector. Given the specificities of the wood sector compared to other sectors, including sanitary and phytosanitary issues, it is appropriate to focus on the impact of these measures on this sector and determine their specific effects. Second, we analyze the duration of the trade relationship between countries using the non-parametric Kaplan- Meier method to estimate the survival function and use a discrete time model to analyze the effect of restrictive SPS measures on the probability of trade failure (trade duration). The analysis on trade duration highlights the long-run performance of trade. As Besedeš and Prusa (2011) point out, especially for emerging countries, long-term export growth depends more on the survival of existing trade relationships than on the establishment of new ones.

Our results show that restrictive SPS measures restrict trade flows of wood and wood products. Using the Kaplan-Meier estimator, we find that trade relationships are short lived. We also find no significant effect of SPS measures on the probability of trade failure.

The remainder of this article is structured as follows: In [section 2.2](#), we review the literature on the effects of these technical measures on trade flows and the analysis of the duration of trade relationships. In [section 2.3](#) and [section 2.4](#), we present our data, our empirical strategy respectively, [section 2.5](#) presents our baseline results, as well as those of the robustness analyses on our baseline results and the results of the trade duration analysis, [section 2.6](#) concludes this study.

2.2 Literature review

This paper provides an empirical analysis of the impact of so-called restrictive SPS measures, which have been the subject of trade concerns in the WTO SPS Committee on trade in wood and wood articles. These measures are considered restrictive to the extent that exporters view them as trade restrictive. Previous studies have mainly focused on the agri-food sector to the detriment of other specific sectors such as the wood sector, which is also affected by SPS measures, whose specific effects on this sector are not highlighted.

Crivelli and Gröschl (2016), Curzi et al. (2020), Fontagné and Orefice (2018), and Fontagné et al. (2015) use the STC database on NTMs, collected from the WTO committees. The use of trade concerns on NTMs has the advantage of allowing the identification of restrictive measures for exporters. In addition, these restrictive measures are bilateral and circumvent the limitations of using data on notifications of NTMs¹. With the exception of Crivelli and Gröschl (2016), these authors focus on the relationship between NTMs and trade flows at the firm level. Indeed, when the data are available, this finer analysis at the firm level allows to show, how firms react to regulations and how the characteristics and heterogeneity of these firms influence the impact of these measures. The size of firms may be determinant in the reaction of firms to regulations. This has been highlighted by Fontagné and Orefice (2018) and Fontagné et al. (2015). In addition, Curzi et al. (2020) focus on the impact of these measures on developing country firms' exports. Curzi et al. (2020) analyze the effects of NTMs on agri-food exports of firms in Peru. Among other things, they show that the probability of trade, firm exit, and export volume decreases with the most restrictive NTMs, with a larger effect for small firms. At the country level, Crivelli and Gröschl (2016) analyze the impact of SPS measures on agri-food trade. They find that aggregate SPS measures have a negative impact on the probability of exporting but increase trade flows provided there is market entry. This literature shows that NTMs measures have varied and complex effects on trade. It is therefore not possible to generalize the trade impact of these measures, which is very heterogeneous.

In addition, the literature has highlighted trade duration as a key determinant of long-

¹These data have a disadvantage in that countries are only required to report measures that are not based on international standards and that affect trade. Thus, some information may be missing from this database and create a potential bias (Fontagné et al., 2015). Similarly, it is not possible to distinguish non-tariff barriers and thus highlight the restrictive nature of these non-tariff measures. The use of these measures does not allow for a bilateral analysis and thus an optimal control of multilateral resistance.

term trade performance (Bao and W.-C. Chen, 2013). Compared to trade value, trade duration identifies the survival of trade relationships between partners over time. In general, trade relationships were identified as being of short duration due to multiple entries and exits (Besedeš and Prusa, 2006a; Hess and Persson, 2011; Nitsch, 2009). Trade duration is the length of time a trade relationship exists between trading partners without interruption. It highlights the length of time that trade between partners can survive being influenced by different factors. Some authors have examined the question of determining the duration of trade relationships in different sectors. Among them, Besedeš and Prusa (2006a,b) analyze the duration of trade on imports in the United States. In particular, Besedeš and Prusa (2006b) determine the extent to which product differentiation affects the duration of US imports. They apply Cox's proportional hazards method and find that trading a differentiated product increases survival in U.S. import markets. The duration of trade can be influenced by different factors such as: level of development, product and trade characteristics, and trade costs as shown by Fugazza, Molina, et al. (2011). Nitsch (2009) applies the stratified Cox proportional hazards model to analyze the trade duration of German imports from 1995 to 2005. He points out that these trade relationships are short, lasting only between one and three years. He also shows that the duration of German imports is influenced by exporter, product and market characteristics.

Moreover, to analyze trade duration and its determinants, more recent studies have looked at other methods of analysis such as, discrete time models to overcome the drawbacks of continuous time models such as the Cox proportional hazards model (Hess and Persson, 2011, 2012; Stirbat et al., 2015; P. Wang et al., 2019). Hess and Persson (2012) point out three main drawbacks of continuous-time models such as the Cox model that justify why this model is not appropriate for analyzing trade duration. The Cox proportional hazards model has problems in the presence of many ties durations, which could lead to biased estimates. In addition, it cannot control for unobserved heterogeneity and imposes a restrictive assumption on the proportional hazards. These authors therefore suggest the use of discrete-time models that provide more robust, unbiased results and take into account unobserved heterogeneity. Hess and Persson (2011) use the discrete-time model to analyze the duration of European Union (EU) imports. In addition, C. Sun and X. Zhang (2018) study the duration of trade in U.S. forest products (wood, paper). They point out that the duration of U.S. forest products trade is short over the period 1996-2016. Using the discrete-time model, they fur-

ther show that distance affects the probability of trade failure.

These studies highlight the importance of analyzing trade duration, which can be influenced by several factors. NTMs have been highlighted as a determinant of the duration of trade between partners. Peterson et al. (2018) analyze the factors that affect the duration of fresh fruit and vegetable exports to the United States. They focus primarily on phytosanitary treatments and show that their impact on trade duration is persistent over time. They triple or quadruple the hazard rate in the early years of the spell. Bao and W.-C. Chen (2013) analyze the impact of TBTs on the duration of trade. They show that TBTs have a positive impact on the volume and duration of existing trade relationships.

In this study, we extend previous studies by determining the effect of SPS measures on trade in wood, wood products, and charcoal, particularly on the value and duration of trade. We use the database of STC raised by WTO SPS committees to account for the restrictive nature of the measures. We estimate a gravity model with the PPML estimator to determine the impact of SPS measures on the value of trade. Using survival analysis, we describe the duration of trade in these products and use a discrete time model to determine the impact of SPS measures on the probability of trade failure.

2.3 Data

In this study, we analyze the effects of SPS measures on trade. We focus mainly on restrictive SPS measures. In order to take into account the restrictiveness of SPS measures, as Curzi et al. (2020) and Fontagné et al. (2015) we use the STC database. This database records all concerns raised by member states in the SPS committees. Indeed, when member states believe that measures adopted by one or more other members are binding on their exports, they raise a concern in the SPS Committee. It provides information on all concerns raised with the SPS Committee. There are approximately 312 STCs in all sectors². The agricultural sector remains the most affected. Unlike other sectors, STCs in the wood sector focus on a part of the sector as a whole, particularly the upstream³. That is, raw, unprocessed or minimally processed products. Thus, the share of STC affecting products remains significant.

²These data are available on: https://www.wto.org/english/res_e/publications_e/wtr12_dataset_e.htm

³In the wood sector, SPS measures, unlike TBT measures, have been the subject of a variety of specific trade concerns, indicating that SPS measures play a key and determining role in the wood trade. These concerns relate in particular to wood and articles of wood; wood charcoal

Using the dates each concern was first raised and the dates each STC was resolved, we expanded and updated the database of STCs raised through 2019. During this period, about 30% of the concerns raised in this sector are marked as resolved or partially resolved by WTO member states in the SPS Committee. For the others, the resolution date is not indicated. The average length of time from the time the issue was first raised to the date of resolution is 6 years. This shows that a significant number of years elapse before concerns are resolved. The specific trade concerns related to wood and articles of wood; wood charcoal are mainly related to plant health, risk assessment, land protection and human health. Indeed, given the phytosanitary risks associated with wood and wood products (wood packaging), which may contain organisms harmful to plant preservation and the environment, several importing countries have adopted SPS measures to limit the spread of these organisms. However, these measures can be trade restrictive and may be a concern raised in the SPS Committee. Each STC thus corresponds to a concern raised by one or more countries in relation to an SPS measure imposed by one or more of their trading partners.

For Fontagné et al. (2015), the advantage of specific trade concerns over traditional notifications or information on the existence of regulations in measuring the restrictiveness of product standards is that they identify measures that are perceived by exporters and/or governments as major barriers to trade ⁴. Like Orefice (2017), we only consider importing countries and products that have been subject to at least one specific trade issue. Orefice (2017) justifies this selection on the grounds that, since STCs are specific and rare events, keeping all possible countries and sectors would result in datasets overinflated by zero. Moreover, The identification of the coefficient is not a function of countries/sectors that have never been affected by STCs due to the use of country/sector fixed effects.

Our trade data are derived from the CEPII BACI database (Gaulier and Zignago, 2010a). This database is based on UN Comtrade trade data and original harmonization methods, offers more exhaustive and reliable data in terms of unit values, because it considers both the information provided by the exporter and the importer. It has the advantage of distinguishing zero or missing flows. We consider products in category 44 of the harmonized system : "Wood and articles of wood; wood charcoal".

⁴To be more realistic and avoid aggregating trade data, we include EU member countries separately. Like (Fontagné et al., 2015), we exclude intra-EU flows from our sample. In WTO committees, EU countries act as a single country.

2.4 Identification and empirical strategy

The objective of our study is to determine the impact of SPS concerns on trade flows and on the duration of these flows over the period 2000-2019 ⁵. First, we analyze the impact of these measures on trade flows. Following the model of Anderson and Van Wincoop (2003, 2004), we estimate a gravity equation as follows:

$$X_{ijt}^k = \exp[\beta_1(\text{SPS})_{ij(t-1)}^k + \beta_2 Y_{ijt} + \beta_3 Z_{ij} + \mu_{it}^k + \nu_{jt}^k + \varepsilon_{ijt}^k] \quad (2.1)$$

X_{ijt}^k represents the exports of country i to country j for product k . $(\text{SPS})_{ij(t-1)}^k$ reports the existence of a concern in the product category k between the country raising concern i (exporter) and the maintaining country j (importer). We consider a one-year lag in our variable. It is likely that an SPS measure at time $t-1$ is exogenous to the export at time t (Fontagné et al., 2015). Y_{ijt} groups time-variant bilateral variables including FTA, which is a binary variable equal to 1 if the countries have a free trade agreement and is obtained from P. Egger and Larch (2008) ⁶. Z_{ij} groups time-invariant bilateral variables such as : bilateral distance, binary variables that are equal to 1 when the countries have a common language, are contiguous and have colonial ties. Scott L. Baier and Jeffrey H. Bergstrand (2007b) point out that the appropriate method to control for the endogeneity of trade policies is to estimate a gravity model with panel data by including country-pair fixed effects. Following Scott L. Baier and Jeffrey H. Bergstrand (2007b), to reduce endogeneity concerns in our analysis (reverse causality) and any unobservable and time-invariant trade costs bias, we replace these time-invariant bilateral variables with country-pair fixed effects. Reverse causality refers to a situation in which a government adopts an SPS measure in response to excessive levels of imports from a country and subsequently a concern is raised about that measure (Fontagné et al., 2015). μ_{it}^k is exporter-product-time fixed effects and ν_{jt}^k is importer-product-time fixed effects. These fixed effects represent inward and outward multilateral resistances that control for specific characteristics that can affect trade on the importer and exporter sides. To estimate this equation, we use the Pseudo-Maximum Likelihood estimator (PPML) (Silva and

⁵Given the lag structure of our variable of interest, we lose one year (i.e. 1999)

⁶These data are available at: <https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.htm> We do not include bilateral tariffs because much of this data is missing from our sample. However, for robustness, we include bilateral tariffs in our estimates.

Tenreyro, 2006). The advantage of this estimator, unlike the standard Ordinary Least Square (OLS) estimator, is that it allows us to take into account zero trade flows that contain information necessary for estimation. This estimator provides robust and unbiased results in the presence of heteroskedasticity and when there is a significant level of zero trade flows as in our sample.

2.5 Results

2.5.1 Baseline results

In this section, we present our baseline results on the impact of SPS measures on trade in wood and wood products. The results of the estimates of the impact of SPS measures on trade are reported in Table 2.1. First, we include only the importer's and exporter's GDP in the estimation without fixed effects (column (1)). The estimated coefficients associated with these controls are consistent with the literature. The coefficient on our variable of interest SPS is not significant. Next, we include the variables: bilateral distance, contiguity, common language, and colonial ties and the FTA without fixed effects (column (2)). The coefficients of the variables, bilateral distance, contiguity and FTA are significant. In column (3), we include importer-product-time and exporter-product-time fixed effects. We find that the coefficients on the variables: bilateral distance, contiguity, FTA, and colonial ties have the expected signs and are significant. Finally, in addition to the importer-product-time and exporter-product-time fixed effects, we include country-pair fixed effects in our estimation to control for the endogeneity of trade policies and any unobservable components of trade costs. These fixed effects have been suggested as a better measure of bilateral trade costs than the standard set of gravity variables (P. H. Egger and Nigai, 2015; Yotov et al., 2016). We consider the results obtained with country-pair fixed effects as our benchmark results.

We find that the coefficient on the SPS measures is negative and significant at the 10% level. These results suggest that restrictive SPS measures have a negative impact on trade flows. For example, the presence of restrictive SPS measures reduces the value of trade by 22.75%⁷. We also find that the coefficient on FTA variable is positive and insignificant. Since

⁷The interpretation of the coefficients of the variable of interest is obtained by doing the following calculation: $[e^{0.205} - 1] \times 100$

Table 2.1: The impact of SPS measures on trade: Baseline results

	PPML Estimates			
	(1)	(2)	(3)	(4)
SPS	-0.125 (0.748)	0.454 (0.709)	-0.118 (0.163)	-0.205* (0.108)
log GDP_importer	0.833*** (0.140)	0.785*** (0.0655)		
Log GDP_exporter	0.578*** (0.0596)	0.490*** (0.0582)		
log Dist		-0.597*** (0.151)	-1.367*** (0.0603)	
Contiguity		1.700*** (0.392)	1.068*** (0.145)	
Common language		0.191 (0.252)	-0.0937 (0.216)	
Colony ties		-0.191 (0.290)	0.607*** (0.140)	
FTA		-1.322*** (0.326)	0.928*** (0.163)	0.0166 (0.0790)
Nbr of Observations	711,969	711,549	641,539	641,152

Note: Robust standard errors in parentheses clustered by country-pair.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is the value of trade flows. Columns (3) and (4) include importer-product-time and exporter-product-time fixed effects. In addition, column (4) also includes country-pair fixed effects. The Stata package `ppmlhdfc` is used for the estimations (Correia et al., 2019). Singleton observations are iteratively eliminated until there are no more singletons. As a result, the number of observations differs across estimates. Incorrect inferences could result from the fact that we retain groups of singletons in multilevel fixed-effects regressions, where the fixed effects are nested within groups. (Correia, 2015).

the FTA variable varies little over time, introducing country pair fixed effects affects the significance of this variable. Our results suggest that SPS measures that are the subject of at least one specific trade concern restrict trade. This result is partly consistent with those found by Fontagné et al. (2015) who find a negative effect of restrictive SPS measures on trade. This result may be explained by the fact that compliance with SPS measures entails higher costs for exporters. These costs may affect a significant proportion of products and have a trade-restrictive effect. Indeed, one of the SPS measures in the wood sector is the use of wood treatment methods to prevent the spread of pests. These treatments can be expensive and

require appropriate infrastructure and changes in production processes. This can be very burdensome for exporters, especially for those who raise this concern. This leads to a decline in trade. The impact of measures on trade depends on a number of factors, including a country's capacity (financial, technical) to comply. They can entail significant costs that can affect a country's ability to comply, especially when they affect a large portion of trade. For example, in November 2000, Canada's representative expressed concern that the European Communities' proposed measures on solid wood packaging materials could have restrictive effects on approximately 69% of Canada's exports to the European Communities. In sum, it could be argued that the costs could be significant enough to reduce the value of trade regardless of the ability of countries to adapt to these measures.

2.5.2 Robustness

In the previous section, we found that restrictive SPS measures have a negative impact on trade. In this section, we perform robustness analyses on our benchmark results with country-pair fixed effects to show that our results are not subject to potential misspecification. In our baseline specification, we did not include bilateral tariffs because these data include a significant number of missing values and vary little over time. Thus, in order to show that our results are not subject to potential bias due to the omission of bilateral tariffs and also to distinguish their impact from that of SPS measures, we include applied bilateral tariffs in our specification. Tariff data are taken from the WITS database and incorporate ad valorem equivalents of non-ad valorem tariff. We use simple average bilateral applied tariffs.⁸ The results are presented in column (1) of [Table 2.2](#). In column (1), we find that SPS measures reduce trade. The coefficient on applied bilateral tariffs is significant at the 1% level, suggesting that trade flows are lower in the presence of bilateral tariffs. The estimated coefficient on the FTA variable is not significant as in our baseline results. This analysis shows that our main results do not suffer from bias due to the omission of tariff data in our specifications.

Bao and Qiu ([2012](#)) have shown that developing countries are the most affected by non-tariff measures, due to their limited technical and financial resources. To test this hypothesis, we create a dummy variable that takes the value 1 when the exporting country is a developed

⁸We also made an estimate using import-weighted bilateral applied tariffs, the results are not different from those we find with simple average bilateral applied tariffs.

country, and 0 otherwise. We include the interaction of this SPS variable in our estimation. The coefficient of the interaction term allows us to test whether the effects of restrictive SPS measures impact exporters differently according to their level of development. The results are presented in column (2) of [Table 2.2](#). We find that the estimated coefficient of our SPS variable is negative and significant as in [Table 2.1](#). That of the FTA variable remains positive and insignificant. The coefficient of the interaction variable is negative and insignificant, suggesting that the impact of SPS measures on trade does not vary according to the level of development of exporting countries.

Table 2.2: The impact of SPS measures on trade: Robustness

	PPML Estimate		PPML Estimate
	Consecutive (2000-2019)	panel	Intervals (2000, 2004, 2008, 2012, 2016)
	(1)	(2)	(3)
SPS	-0.216* (0.124)	-0.197* (0.112)	-0.330** (0.137)
FTA	-0.114 (0.0885)	0.0166 (0.0790)	0.0577 (0.114)
ln(1+tariff)	-0.153*** (0.0472)		
SPS*Dev_exporter		-0.0804 (0.256)	
Nbr of Observations	297,441	641,152	157,457

Note: Robust standard errors in parentheses clustered by country-pair.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-product- time, exporter-product-time fixed effects and country-pair fixed effects. The dependent variable is the value of trade flows. We do not include the Dev_exporter variable in the estimation because it is collinear with fixed effects. The Stata package `ppmlhdfc` is used for the estimations (Correia et al., [2019](#)). Singleton observations are iteratively eliminated until there are no more singletons. As a result, the number of observations differs across estimates. Incorrect inferences could result from the fact that we retain groups of singletons in multilevel fixed-effects regressions, where the fixed effects are nested within groups. (Correia, [2015](#)).

Futhermore, SPS measures are adaptive and can be implemented over time. Thus, the effects of these measures are arguably not immediate in the sense that there will be a period of adjustment in trade flows in response to these measures. Thus, in order to account

for this adjustment time, Yotov et al. (2016) suggest using panel data with intervals. Thus, for robustness, we use our data at 4-year intervals (2000, 2004, 2008, 2012, 2016). The results are presented in the column (3) of Table 2.2. The estimated coefficient of our variable of interest is significant and negative as in Table 2.1.

In sum, we find that our main results are robust, with the results remaining generally consistent with these robustness analyses.

2.5.3 Duration

In this section, we analyze trade duration and the effect of SPS measures on trade failure.

Kaplan-Meier estimators

Trade duration indicates the number of consecutive periods (years) of uninterrupted trade relations, i.e. without zero trade flows. To analyze trade duration, authors such as Besedeš and Prusa (2006a) and Nitsch (2009) use survival analysis methods. Duration can be modeled as a sequence of conditional probabilities that a trade relationship will continue after t periods (Besedeš and Prusa, 2006a; Nitsch, 2009). The survivor function is as follows:

$$S_t = Pr(T \geq t) \quad (2.2)$$

T is a random variable that represents the length to the end of the trade. The hazard function measures the conditional probability that the trade will stop after period t given that it has survived to that point:

$$\lambda(t) = Pr(T = t | T \geq t) \quad (2.3)$$

To estimate these functions, the non-parametric Kaplan-Meier estimator is used in the literature (Besedeš and Prusa, 2006a; Nitsch, 2009). In this analysis, we also use this estimator.

Since our trade flow data are annual, the duration of trade will therefore be expressed in years. For example, a trade relationship observed in 2000-2007 will correspond to a trade duration of 8 years. Furthermore, it should be noted that the analysis of the duration of a trade relationship is subject to the presence of censoring, namely the left censoring and the right censoring. The left censoring refers to the fact that the beginning of the trade relationship is not known. In other words, a trade relationship is observed from the first analysis period

but it is not known whether the relationship began before the analysis period. Right censoring means that the exact end of the trade period is not known; trade does not cease at the end of the analysis period. Thus, the interpretation of the length of the trade relationship should be at least 8 years instead of exactly 8 years. Hess and Persson (2011) point out that right-censored observations are not problematic and can be included in the analyses. For left-censored observations, it is common to exclude them from the analyses to avoid any restrictive a priori assumptions about the hazard rate (Hess and Persson, 2011, 2012). In our analysis, all left-censored observations are excluded and right-censored observations are included in our analysis. A binary variable is created in the estimation technique for survival methods to account for this right censoring. Besedeš and Prusa (2006a) argue that “the Kaplan-Meier estimator is robust to censoring and uses information from both censored and uncensored observations.”

Moreover, in trade relationships, it is possible to observe multiple trade periods. Indeed, for a specific product, a trade relationship between partners can stop for one or more years and then resume. Multiple periods are treated as independent. Table 2.3 presents the values of trade duration and those of the kaplan meier estimators for specific years. Figures 2-4 give a graphical representation of these estimates.

Table 2.3: Trade Duration and Estimated Kaplan-Meier survival rate

	Survival time (Trade duration, years)		Estimated Kaplan-Meier survival rate				
	Mean	Median	1st	3	5	10	19
Benchmark	3.32	1	0.46	0.21	0.14	0.08	0.06
Only single spell	4.13	1	0.40	0.22	0.18	0.15	0.13
First Spell	2.9	1	0.40	0.18	0.12	0.07	0.05

For our benchmark sample, we find that the mean trade duration between country pairs is 3.32. The median trade duration is 1. In our analysis, we considered multiple spells for the same country pairs as independent and the duration, if any, as independent of the number of spells. As Besedeš and Prusa (2006a), we also analyze the trade duration by considering on the one hand only single spell and on the other hand the first spell of multiple spell relationships (First spell). We find for the only single spell, a mean trade duration of 4.13. For the first spell, the mean trade duration is estimated at 2.9. For both, the median duration is

the same as for our benchmark sample. With respect to the Kaplan-Meier survival rate estimates (table and graphs), we find, for our benchmark sample (Figure 2.1) that 46% of trade relationships survive after the first year (more than one year), compared to 40% (Figure 2.2) for only single spell and 40% for first spell (Figure 2.3). In other words, for our benchmark data, after the first year, 54% of trade failures are realized. It is estimated that only about 6% of spells survive to the end of the period, with slightly more for single spell. In sum, we find little difference between the results of our benchmark sample and the alternative analyses (Only single spell and First spell). The multiple spells observations do not significantly alter the overall spell length.

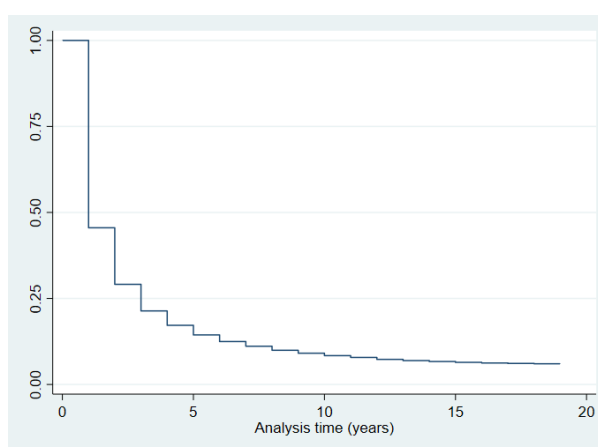


Figure 2.1: Kaplan-Meier survival estimates / benchmark

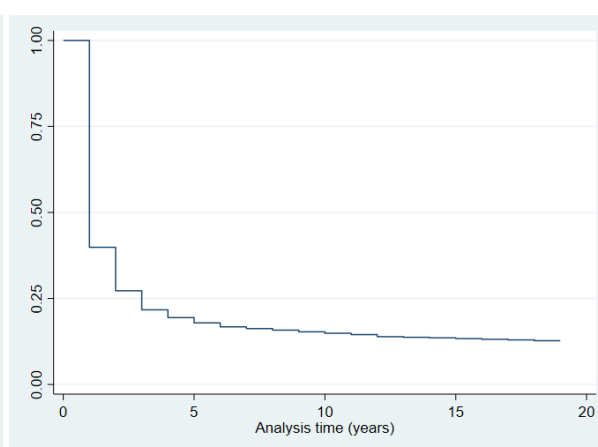


Figure 2.2: Kaplan-Meier survival estimates / Single spell

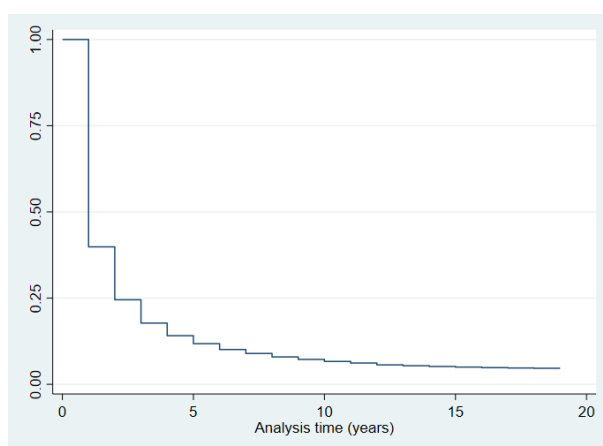


Figure 2.3: Kaplan-Meier survival estimates / First spell

In summary, we find that trade flows of wood and wood articles are short-lived. The median duration is 1 year. This is consistent with the results of Hess and Persson (2011), who found that EU imports from around the world are short-lived, and Nitsch (2009), who found that German imports are also short-lived. On average, trade flows are found to be short-lived.

Regression analysis-Discrete-time hazard model

The Kaplan-Meier estimator is useful for describing trade survival patterns. However, as Peterson et al. (2018) point out, this estimator does not account for additional factors that affect trade. Thus, to overcome this limitation, several authors (Besedeš and Prusa, 2006b; Fugazza, Molina, et al., 2011; Nitsch, 2009) have used a continuous-time duration model, specifically the Cox proportional hazard model. Hess and Persson (2012) show that the Cox proportional hazard model has limitations and is not appropriate for analyzing trade duration on large trade data sets and suggest using discrete time models to control for unobserved heterogeneity and obtain robust and unbiased results. Thus, following Hess and Persson (2012), we use discrete-time duration models and controlling for unobserved heterogeneity to analyze the impact of SPS measures on trade duration. For Hess and Persson (2012), the analysis with the discrete-time hazard model is based on the fact that duration is constituted by the probability that a particular trade relationship will end in a given time interval $[t_s, t_s + 1]$, $s=1,2,...s^{max}$ and $t_1=0$, conditional on its survival up to the beginning of the interval and given the explanatory variables included in the models. Hess and Persson (2012) define the conditional probability named the discrete-time hazard rate as follows:

$$h_{is} = P(T_i < t_{s+1} | T_i \geq t_s, x_{is}) = F(x'_{is}\beta + \gamma s) \quad (2.4)$$

T_i is a continuous, non-negative random variable that measures the survival time of a particular trade relationship. x_{is} is the vector of covariates (possibly time-varying), γs allows the hazard rate to vary from one period to another. Since the base hazard rate is unknown, it can be incorporated into the model as a set of dummy variables that mark the duration of each spell or by specifying a functional form to reduce the number of model parameters. $F(\cdot)$ is a distribution function that ensures that $0 \leq h_{is} \leq 1$. Hess and Persson (2012) introduce the log-likelihood function for the discrete-time duration model as follows:

$$Ln\mathcal{L} = \sum_{i=1}^n \sum_{t=1}^t [y_{it} \ln(h_{it}) + (1 - y_{it}) \ln(1 - h_{it})] \quad (2.5)$$

y_{it} a dummy variable taking the value of 1 when the trade spell ends in the t^{th} time interval and zero otherwise. In addition, to estimate the model parameters, it is necessary to specify the functional form of the hazard rate. This can be specified in several ways. The most commonly used are the distribution functions leading to estimators for the binary panel regression models, probit (normal), logit (logistic) and Cloglog (extreme value). In our study, we use the probit estimator as the main estimator following the example of Hess and Persson (2012). Hess and Persson (2012) justify the use of this estimator by the fact that it allows explicitly taking into account the unobserved heterogeneity.

Our discrete time hazard function specification is as follows:

$$y_{ijt}^k = \beta_1 (SPS)_{ij(t-1)}^k + \beta_2 Duration_{ijt}^k + \beta_3 X_{ijt} + \beta_4 Z_{ij} + \alpha_t + \alpha_k + \alpha_{spell.num} + \varepsilon_{ijt}^k \quad (2.6)$$

y_{ijt}^k is equal to one if a trade relationship of product k (spell) between importer j and exporter i ends at time t and zero otherwise. $(SPS)_{ij(t-1)}^k$ reports the existence of a concern in the product category k between the country raising concern i (exporter) and the maintaining country j (importer). Following Peterson et al. (2018), we include in our model $Duration_{ijt}^k$ variable which is the number of years in the current spell to control for duration dependence. X_{ijt} groups time-variant bilateral variables including FTA, which is a binary variable equal to 1 if the countries have a free trade agreement. We include also initial trade value variable, which is the logarithm of the trade value at the beginning of the spell. Besedeš and Prusa (2006b) and Hess and Persson (2011) find that trade relationships that begin with either a large initial trade value decrease the risk of trade failure. Z_{ij} groups time invariant bilateral variables such as : bilateral distance, binary variables that are equal to 1 when the countries have a common language, are contiguous and have colonial ties. α_t is year dummy variable, α_k is product dummy variable. As Peterson et al. (2018) we include these dummy variables to capture factors that are related to a given trade relationship. $\alpha_{spell.num}$ is a dummy variable of the number of spells. Since we assume that all our spells are independent. This dummy variable is introduced to account for multiple spells. ε_{ijt}^k is a error term.

Regarding unobserved heterogeneity, one method to account for it is to use fixed effects. However, the fixed effects model with logit, probit or cloglog estimators will be subject to the problem of incidental parameters. Indeed, obtaining consistency in the estimated coefficients requires that the number of individuals and periods extend to infinity because of the non-linear pattern of these estimators (Peterson et al., 2018). According to Peterson et al. (2018), one way around this problem is to use the random-effects estimator and test if the estimated fraction of the error variance that is due to variation in the unobserved individual factors, ρ is equal to zero⁹. We therefore use the random-effect probit estimator to account for unobserved heterogeneity.

⁹In all estimates of discrete-time hazard functions, the null hypothesis of ρ equal to zero could not be rejected.

Table 2.4: The impact of SPS measures on trade duration

	Probit	Logit	Cloglog
	(1)	(2)	(3)
SPS	-0.109 (0.123)	-0.152 (0.219)	-0.0841 (0.149)
Duration	-0.245*** (0.00179)	-0.519*** (0.00426)	-0.455*** (0.00351)
Log GDP (importer)	-0.0202*** (0.00336)	-0.0235*** (0.00592)	-0.0116*** (0.00407)
Log GDP (exporter)	-0.0298*** (0.00351)	-0.0385*** (0.00618)	-0.0202*** (0.00425)
Log distance	-0.00864 (0.00678)	-0.0496*** (0.0121)	-0.0646*** (0.00851)
Contiguity	-0.0641** (0.0286)	-0.0782 (0.0510)	-0.0454 (0.0377)
Common language	-0.0317 (0.0211)	-0.0571 (0.0369)	-0.0325 (0.0252)
Colony ties	0.0162 (0.0393)	0.0233 (0.0702)	0.0389 (0.0509)
FTA	-0.0954*** (0.0162)	-0.167*** (0.0285)	-0.124*** (0.0198)
Initial_trade	-0.00897*** (0.00225)	-0.00819** (0.00398)	0.000358 (0.00273)
ρ	3.64E-07	4.09E-07	4.76E-08
Year dummies	Yes	Yes	Yes
product dummies	Yes	Yes	Yes
Spell num. dummies	Yes	Yes	Yes
Log-Likelihood	-36899.767	-35577.781	-34458.585
Observations	140,656	140,656	140,656

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. ρ indicates the fraction of the error variance that is due to unobserved countries-product factors. "A value of ρ equal to zero implies that the fixed effect is not correlated with any of the independent variables" (Peterson et al., 2018). In all estimates of discrete-time hazard functions, the null hypothesis of ρ equal to zero could not be rejected.

For robustness, we use the logit and cloglog estimators. The results of the estimations are reported in Table 2.4.

As for the interpretation of the results, a positive sign of the estimated coefficients means a

lower probability of trade spell survival (higher probability of trade failure). A negative sign means a higher probability of survival of the trade spell (lower probability of trade failure). The results obtained with the random-effect probit estimator are considered as our main results and we comment on them. The results obtained with the other estimators are only slightly different from our main results. When we focus on our control variables, duration, importer and exporter GDP, contiguity, FTA, and initial trade have the expected sign and are significant. For example, the estimated coefficient for FTA is negative and significant, meaning that FTA improves the survival rate of trade. In other words, the more countries have a free trade agreement, the longer trade lasts. This is consistent with the literature that has shown that FTAs promote trade (Scott L Baier and Jeffrey H Bergstrand, 2007a). With respect to the GDPs of importers and exporters, which are indicators of the economic size of countries, these results suggest that trade involving large importers and exporters is likely to last. For our variable of interest, SPS, the estimated coefficient is negative and insignificant, suggesting that restrictive SPS measures have no impact on the hazard rate. It is conceivable that, to the extent that restrictive SPS measures require an adjustment period, the effect of these measures on the hazard rate may depend on the duration of the trade. We test this hypothesis by interacting our variable of interest with our duration variable. The estimation results with the interaction variable are presented in Table B.3 in the appendix. The estimated coefficients of our SPS variable of interest and the interaction variable are not significant. We find that restrictive SPS measures do not have a significant impact on the survival rate of trade .

2.6 Conclusion

In this paper, we analyze the impact of SPS measures on trade flows of wood and wood products and the duration of these trade flows. We use the STC database to account for the restrictive nature of these SPS measures. First, we use a gravity model to determine the effect on trade of the presence of trade concerns related to SPS measures. We find that restrictive SPS measures limit trade flows. SPS measures can lead to burdensome compliance costs associated with lengthy administrative procedures, which can lead to reduced trade flows. These results are robust to sensitivity analyses, including consideration of bilateral tariffs and 4-year data intervals. Second, we describe the duration of trade relationships using the

Kaplan-Meier estimator and determine the effect of these SPS measures on trade duration. We find that the median duration of trade relationships is one year. In other words, trade relationships are of short-lived. We find that SPS measures have no significant effect on the probability of trade survival. Our results suggest that SPS measures can be discriminatory and constitute barriers to trade by creating costs that burden countries. These measures should be harmonized and made more understandable so that adaptation procedures are less time consuming and costly.

Part 2 Trade Instruments Related to Sustainability, Illegal Logging and Trade in Wood and Wood products

Illegal logging is a threat to the sustainability of forests. International trade remains the main means by which illegally sourced timber and timber products move from one country to another. The United States, the European Union, Australia and the Republic of Korea have all introduced timber regulations to prevent the import of illegal timber and consequent deforestation. On the other hand, forest certification appears to be an indispensable market tool, aimed not only at promoting sustainable forest management and better use of the services they provide, but also as an instrument of market performance. This second part of this thesis is divided into two chapters (chapters 3 and 4), which identify the role of these policy instruments on trade. In the third chapter, we analyze the impact of timber regulations on exports of timber and timber products from countries where illegal logging is widespread. In the fourth chapter, we focus on the impact of forest management certification on exports of wood and wood products by French firms.

The Impact of Timber Trade Regulations on Timber and Timber Products Trade

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3.1 Introduction

Deforestation is a growing threat to global biodiversity (Jean-Louis Combes et al., 2020; FAO, 2020). According to statistics, deforestation is estimated to cause a loss of 46 to 58 thousand square miles of forest per year (E. A. Adams, 2012; Bennett, 2017), and the rate of deforestation was identified at 10 million hectares per year between 2015 and 2020 by FAO (2020). Deforestation raises climate change issues (Gatti et al., 2021), threatens biodiversity conservation, and promotes the spread of infectious diseases that harm human health and the economy (FAO, 2022; Santos and Almeida, 2018; Tacconi, 2007). Due to the urgency of the situation, several studies have been dedicated to understanding the causes of the phenomenon. Among the major causes, the analyses point to the illegal timber and timber product trade, which represents almost half of world trade (Acheampong and Maryudi, 2020; Bösch, 2021; B. Chen et al., 2021; Tacconi et al., 2019).¹

To regulate the world timber and timber product trade and thus limit the progression

¹Illegal logging refers to logging through any means without authorization and without respect for national or international rules for the production and extraction of timber from the forest but also to all the intermediate steps that the timber may undergo until it reaches the consumer (Brack, 2003).

of the loss of forest cover and its associated consequences, many (large) importing countries have implemented various reforms (Harris, 2022). The starting point was the 1998 G8 agenda, which emphasized the need to combat illegal logging. As a result, some timber-consuming or timber-importing countries have put policies in place to combat illegal logging. These policies focus on controlling international trade to promote the legal timber trade. The United States, the European Union (EU), Australia, South Korea, and Japan have implemented regulations to ban illegal timber in their respective markets. In 2008, the United States, with the amendment of the Lacey Act, became the first country to ban the import and sale of illegally sourced timber and timber products (Lawson and MacFaul, 2010). This regulation served as an example for the one put in place by the EU. The European Union Timber Regulation (EUTR) came into force in 2013 to prohibit illegally obtained timber and timber products from being placed on the EU market. Both regulations, therefore, encourage verification of legality as a measure to access the European and U.S. markets (Fernández et al., 2021; Jonsson et al., 2015; Leipold et al., 2016). In addition, the Illegal Logging Prohibition Regulations 2012 in Australia, South Korea's Sustainable Timber Use Act, and the Clean Wood Act in Japan have also put measures in place to promote legal imports of timber and timber products. These regulations, with the exception of South Korea's, require the application of due diligence or due care system (United States) based on a set of appropriate information and tools to assess the risks and determine the origin and legality of timber and timber products (Fernández et al., 2021; Jonsson et al., 2015). Unlike the other regulations mentioned, the Clean Wood Act in Japan is still awaiting full implementation and is not a mandatory system to combat illegal logging but a voluntary registration system for firms that import and trade timber and timber products domestically (Fernández et al., 2021).

The literature on the effect of these regulations on trade is relatively nascent but growing. For example, in a descriptive study, Pepke et al. (2015) highlight that timber regulations influence supply chain actors' knowledge and awareness of the effects of illegal logging and trade. Using the case of the EUTR and the specific case of Germany, Köthke (2020) stresses that timber and timber product trade regulations changed the behavior of the German timber industry, especially among large companies and those importing timber from risk countries. Nathan et al. (2018) found that timber regulation promotes greater awareness of legal verification requirements and how to comply with them, which could have a spillover effect on the domestic market. Furthermore, Masiero et al. (2015), Villanueva et al. (2023), Preste-

mon (2015), Giurca et al. (2013) and Rougieux and Jonsson (2021) highlight that timber regulations reduce the amount of timber entering the market. This may be due to a decrease in timber exports from countries suspected of illegal logging and thus a removal of illegally produced timber from exports (Prestemon, 2015). Based on the EU timber regulatory framework, Zeitlin and Overdevest (2021) emphasize that the regulation changed the architecture of timber management by fostering productive interactions with both public regulation of timber legality in other consuming countries as well as with private certification systems. This observation of the role of timber regulation and timber products on the legality or governance of timber is shared by authors such as M. A. Adams et al., 2020, Astana et al., 2020, and Cerutti et al., 2021

The literature, although rich, presents two major limitations. On the one hand, the existing studies are descriptive and lack a clear method for analyzing the link between these reforms and timber and timber product trade flows. On the other hand, the analyses conducted have focused on country/regional cases (see, for example, Villanueva et al., 2023 for discussion), limiting their external validity. Although the objective of this study is to determine, through an empirical analysis, the impact of the implementation of regulations imposed by the United States, the EU, Australia, and South Korea on the trade of timber and timber products, our contribution to the literature is more specific. Indeed, in this paper, we contribute to the literature by proposing a methodological approach combining a matching approach, notably the entropy balancing developed by Hainmueller, 2012, with a gravity model method to assess the effect of these reforms.

Based on the literature, the link between timber trade regulations and timber and timber product trade can be discussed theoretically in the following way. First, these regulations are similar to a sanction that the importing country can impose on the exports of a partner country. Indeed, noncompliance with the measures related to the regulation exposes the exporting country to consequences such as exclusion from the market of the regulating country. Thus, the due diligence imposed by these reforms and the threats associated with them can push the exporting country to better manage its trade and thus control illegal logging, which accounts for nearly 80% of the exports of some countries, such as Indonesia.² Second, the implementation of these regulations will result in significant costs, compliance, and enforcement delays, in particular, reducing trade between the reform country and its part-

²<https://eia-international.org/forests/the-ongoing-threat-to-indonesias-legal-timber-trade/>

ners (Acheampong and Maryudi, 2020; Brusselaers and Buysse, 2021; Rougieux and Jonsson, 2021). Third, these measures could encourage exporters to move to less restrictive markets and thus export less to countries imposing the measures Acheampong and Maryudi (2020), Giurca et al. (2013), Masiero et al. (2015), Partzsch et al. (2023), and Rougieux and Jonsson (2021).

To conduct our analysis, we use data for the period 1995-2019, focusing on the imports of 40 countries from countries identified as more likely to export illegal timber and timber products by applying the entropy balancing method combined with the gravity approach. The risk countries that export more illegal timber or timber products are Indonesia, Brazil, Malaysia, the Democratic Republic of Congo (DRC), Ghana, Laos, Papua New Guinea, the Republic of Congo, Cameroon, China, Thailand, and Vietnam (Hoare, 2015). We test the robustness of our results not only by estimating alternative specifications but also by using complementary methods such as the gravity model and ordinary least squares (OLS). Second, we analyze the differential impact of these regulations on trade for the various timber and timber product subsectors involved and determine the separate effect of each measure on trade.

The rest of this paper is structured as follows, [section 3.2](#) and [section 3.3](#) present the data and methodology, [section 3.4](#) presents the baseline results, [section 3.5](#) presents the results of the robustness tests, [section 3.6](#) presents the results of the heterogeneity analysis, [section 3.7](#) presents a discussion of the methodological interest and limitations of our paper, and [section 3.8](#) concludes this study.

3.2 Data

The variables used in this paper are presented as follows.

- Dependent variable

Our dependent variable is the value of trade. The trade data are taken from the BACI database on timber and timber product trade over the period 1995-2019 (Gaulier and Zignago, 2010b).

In this database, products are classified according to the Harmonized System (HS) classification. The products affected by timber regulations are mainly included in the two-digit HS categories 44, 47, 48, and 94, which are considered subsectors in our analysis. These products are timber, timber products, pulp, paperboard, and wooden furniture. The advantage of using the BACI database rather than the Comtrade database is that it fills in the missing trade data streams, as it uses mirroring and other processing to ensure consistency and relevance of the data.

– Treatment variable

Our interest or treatment variable, named enforcement, is a dummy variable that reflects the existence of timber and timber product regulations enforced by importing countries. We construct it as a variable taking 1 if an importing country j imposes timber regulations on its imports from a country i at year t . Data come from various government websites and archives.

– Independent variables

Based on the literature, we select a set of control variables for our baseline model that can influence the implementation of enforcement and/or trade flows of timber and timber products. We use GDP, forest area, poverty gap index, level of corruption index, and exchange rate. Data for these variables are taken from the World Development Indicators (WDI) and Worldwide Governance Indicators database. We also use the climate change readiness compiled by the University of Notre Dame. The intuition behind the use of the poverty gap and the level of corruption in particular for exporting countries is that, as the literature points out, corruption (or institution) and poverty are one of the causes of illegal logging and thus of the illegal timber trade (Alemagi and Kozak, 2010; Amin et al., 2019; Araujo et al., 2011, 2005, 2008, 2009, 2019; Barbier and Burgess, 2001; Bouriaud, 2005; Combes et al., 2015; Culas, 2007; De Los Rios, 2022; Kere et al., 2017). Climate variables are included to capture their role in driving forest protection. Indeed, it is generally acknowledged that forests offer protection against global warming through carbon retention (Ellison et al., 2017; Villanueva et al., 2023). Thus, an increase in climate problems may lead countries to implement regulations to control timber and timber product trade. We include the forest cover, as the speed

of forest loss can reinforce the need for regulations to preserve it. Next, we include GDP to capture country size, as gravity theory claims that large countries are more likely to engage in international trade. Finally, we include the exchange rate to capture its effect on trade flows as stated by Gupta and Kumar (2021) but also on forest management and the timber trade (Prasada et al., 2022; Richards et al., 2012).

For robustness, we include in our baseline estimation other control variables such as the poverty gap and corruption level of the importing country, the climate change vulnerability index, the rule of law index, the regulatory quality index of the importing and exporting countries, bilateral tariff and the standard gravity model variables (distance, colonial ties, common language, and contiguity). The data on distance, colonial ties, common language, and contiguity are from the Center for International Prospective Research and Data (CEPII). Bilateral tariffs were extracted from The World Integrated Trade Solution (WITS) database.

3.3 Methodology: entropy balancing

The aim of this study is to assess the effect of the implementation of timber and timber product trade regulations named enforcement. However, an identification challenge arises in analyzing the relationship between enforcement and timber and timber product trade, as the introduction of such reform is hardly exogenous. Indeed, the implementation of the regulation may depend on several factors, such as the flows of illegal timber and timber products to the countries implementing the regulation, the economic situation of the exporting country, and the forest cover of the exporting country, for example, making its introduction nonrandom due to a selection bias.

An illustration of this identification problem can be drawn by analyzing our research data. The first threat to the inference is the large difference in observed covariates between units exposed to enforcement and those not exposed to enforcement. Indeed, our preliminary examination presented in Panel A of Table 1 shows that observations subject to enforcement are different in terms of GDP, forest cover, resilience to climate change, poverty level, institutional quality, and exchange rate. Indeed, Columns (1), (2), and (3) present, respectively, the sample means for country-pair-year observations for the treatment period/group (with enforcement), the control period/country (without enforcement), and the difference

between these two. The results reveal a difference between enforcement and nonenforcement units. In particular, the enforcement units are characterized by high GDP, high forest area coverage in the exporting countries,³ high resilience (readiness), low forest area coverage in the importing countries, low poverty, low corruption, and a high exchange rate. In econometric terms, the observations are unbalanced with respect to the enforcement dummy variable. This threatens our conclusions if these observed differences are also correlated with differences in timber and timber product trade (Allcott, 2015; Baccini et al., 2019) or if they reflect unobserved differences that might drive the correlation between enforcement and trade in timber and timber products. Moreover, these differences indicate that enforcement is not random and is susceptible to an endogeneity problem, namely, selection bias.⁴ To circumvent this problem, we build on the literature by combining the gravity approach with a matching technique such as the entropy balancing developed by Hainmueller, 2012. This method reweights the observations with respect to the treatment, i.e., enforcement, to ensure that all relevant covariates are balanced, i.e., have the same mean. In econometric terms, entropy balancing reweights observations to statistically generate a common support region where the enforcement and nonenforcement units are similar on our covariates. To achieve this, entropy balancing directly incorporates the covariate balance into the weighting function applied to the sample units and produces data in which two-unit groups can be compared.

We test the performance of entropy balancing using Panel B of Table 1, which shows the results of entropy balancing after weighting. A closer look at this table shows that the difference in means between the enforcement and nonenforcement observations in Panel A of this table is reduced and never significantly different from zero. Consequently, entropy balancing allows us to construct a perfect control group that is closely similar to the treatment units on the basis of all covariates and allows us to evaluate the effect of the regulation of timber and timber products by mitigating the endogeneity issues previously highlighted.⁵

³However, the difference is not statistically significant

⁴These differences across enforcement and nonenforcement units demonstrate the importance of selecting an appropriate control group when computing the treatment effect of enforcement to avoid incorrectly estimated treatment effects.

⁵This method offers some advantages over competing impact analysis methods such as propensity score matching (PSM) or "simple" regression methods such as Ordinary Least Squares or difference-in-differences. First, it allows for a high degree of balance between the treatment and control units by creating a synthetic group that is as close as possible to the treatment group. Second, unlike other methods such as propensity score matching, OLS, or difference-in-differences, this method does not require the construction of an empirical model for enforcement, thus limiting specification and multicollinearity problems. Third, unlike traditional matching methods, entropy balancing uses a more flexible reweighting method by keeping the weights closer

The approach used in this study is based on the principle that enforcement is the treatment and the trade of timber and timber products is the outcome variable. The units of observation are country i –country j –year observations. Thus, country i –country j –year observations with enforcement constitute the treatment group, and those without enforcement constitute the control group. The treatment effect of enforcement on timber and timber product trade (ATT) is defined as the following conditional difference:

$$\tau_{ATT} = E[Y_{ij}(1) | T = 1, X = x] - E[Y_{ij}(0) | T = 0, X = x] \quad (3.1)$$

where the first component is the average bilateral trade flows (Y_{ij}) conditional on the treatment characteristics ($X = x$) during the enforcement period ($T = 1$), and the second is bilateral trade flows of the reweighted (synthetic) control group.

τ_{ATT} is estimated using the differences in average outcomes between the treatment group and the reweighted control group, which is the estimated impact of enforcement on bilateral timber and timber product trade. Concretely, τ_{ATT} is the difference in means between the bilateral trade flow (Y_{ij}) between countries i and j in the treatment period ($T = 1$, i.e., when enforcement is in place) and the control period ($T = 0$, i.e., when there is no enforcement) conditional on a vector of covariates ($X = x$).

A survey of the literature shows that entropy balancing is widely used in many existing studies. For example, in the international economics/politics literature, authors rely on this approach to identify the effect of various policies. For instance, based on 89 developing countries over the period 1982-2011, Neuenkirch and Neumeier (2016) use entropy balancing to show that economic sanctions increase poverty. In similar literature, Afesorgbor (2019) and Baronchelli et al. (2022) use the same method to analyze the effect of sanctions on international trade. Baccini et al. (2019), P. H. Egger and Tarlea (2021), and Fageda and Teixidó (2022), and Apeti (2023b) used this approach to analyze the effect of Vietnam's accession to the WTO in 2007 on state-owned enterprises, the European Union's Emissions Trading Scheme (EU ETS) on pollution issues, Preferential Economic Integration Agreements (PEIAs) on trade costs and trade flows, and sovereign external debt default on inequality. Ogrokhina

to the base weights to avoid information loss. The fourth advantage is that, unlike classical matching which is based on the assumption of conditional independence, entropy balancing allows us to exploit the panel aspect of our data and control for time and country-pairs fixed effects in our regression.

and Rodriguez (2019) used this matching approach to analyze the joint effect of inflation targeting and financial openness on the currency composition of sovereign debt. Finally, Apeti (2023a) and Apeti and Edoh (2023) recently used this approach to identify the effect of financial innovations such as mobile money on the volatility of household consumption and public revenue mobilization, respectively.

The identification of covariates that may influence the implementation of the enforcement and/or trade flows of timber and timber products previously used in the baseline model, including the size of the economy or level of development as measured by GDP, forest area, climate change readiness, poverty gap, corruption index of the exporting country, and exchange rate, is derived from the literature previously discussed. To test the robustness of our findings, we augment our baseline specification with the following variables: poverty gap, the corruption index of the importing country, vulnerability index, rule of law, regulatory quality index, bilateral tariffs, and the standard variables of gravity model, namely, distance, contiguity, common language, colony ties, and RTA. As Afesorgbor (2019), we also control for country-pair fixed effects to control for time-invariant unobserved variables and time-fixed effects.⁶

⁶P. H. Egger and Nigai (2015) and Yotov et al. (2016) suggest these fixed effects as a better measure of bilateral trade costs and time-fixed effects to control for global trends.

Table 3.1: Covariates balance

Panel A: Descriptive statistics before weighting.			
VARIABLES	(1) Enforcement	(2) No enforcement	(3) Diff
Log GDP_Importer	19.57	19.51	-0.06***
Log GDP_Exporter	19.29	18.15	-1.14***
Log forest_area_importer	10.17	10.5	0.33***
Log forest_area_exporter	12.86	12.8	-0.06
Readiness_importer	0.6426	0.5998	-0.04***
Readiness_exporter	0.3779	0.362	-0.02***
Poverty_gap_exporter	4.224	7.352	3.13***
Corruption_exporter	-0.5218	-0.5656	-0.04
Log exchange rate	3.888	2.923	-0.97***
Observations	1867	6093	
Panel B: Descriptive statistics after weighting.			
VARIABLES	(1) Enforcement	(2) Synthetic control	(3) Diff
Log GDP_Importer	19.57	19.57	0
Log GDP_Exporter	19.29	19.26	-0.03
Log forest_area_importer	10.17	10.18	0.01
Log forest_area_exporter	12.86	12.87	0.01
Readiness_importer	0.6426	0.6419	0.00
Readiness_exporter	0.3779	0.3774	0.00
Poverty_gap_exporter	4.224	4.337	0.11
Corruption_exporter	-0.5218	-0.5229	0.00
Log exchange rate	3.888	3.855	-0.03
Observations	1867	6093	
Total of Weights	1867	1867	

3.4 Results

Using the synthetic controls in [Table 1 \(Panel B\)](#), we study the effect of the enforcement of the regulation of trade in timber and timber products (ATT). The results are presented in [Table 2](#). Column (1) presents the findings of our baseline specification. In addition to the

enforcement dummy, we include the covariates used in the first step, i.e. [Table 1 \(Panel B\)](#), namely, GDP, forest area, readiness, poverty gap, corruption, and exchange rate, to improve the quality of the estimation. The conclusions indicate that enforcement reduces timber and timber product trade flows between countries with this reform and their trading partners. Next, we test the robustness of this conclusion with additional control variables. To do so, we add poverty gap, corruption index, vulnerability index, rule of law, regulatory quality index, and tariff to the baseline model one at a time and simultaneously (Columns (2)-(8)). The results of these specifications present similar conclusions to those in Column (1). Finally, we test the robustness of our baseline specification to some standard gravity model variables, notably distance, contiguity, common language, colony ties, and RTA (Column (9)). The results highlighted in Column (9) of [Table 3.2](#) provide similar conclusions to those in Column (1): enforcement reduces the flow of trade in timber and timber products, which supports our hypothesis.

Table 3.2: Regulations and timber and timber product trade

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES									
Enforcement	-0.261*** (0.0491)	-0.328*** (0.0485)	-0.240*** (0.0504)	-0.213*** (0.0469)	-0.170*** (0.0517)	-0.244*** (0.0488)	-0.257*** (0.0405)	-0.383*** (0.0523)	-0.587*** (0.0819)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,157	6,715	7,141	7,141	7,152	7,141	6,208	5,819	7,157
R-squared	0.947	0.947	0.948	0.947	0.947	0.947	0.963	0.966	0.752
Country-pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Our dependent variable is the logarithm of value of trade. Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (Column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariff (Column (7)), and all the variables (Column (8)). In Column 9, we replace the country-pair fixed effects by the country-pair gravity variables (log distance, contiguity, common language, colony ties, RTA).

3.5 Robustness

3.5.1 Alternative specifications

The previous section uses baseline results and robustness tests performed by adding additional control variables to show that enforcement decreases timber and timber product imports of enforcement countries from their trading partners. In this section, we supplement the robustness set already constructed by testing some alternative specifications. First, we test the so-called Ashenfelter dip (Abadie, 2005; Afesorgbor, 2019; Ashenfelter, 1978; Bruinshoofd and Ter Weel, 2003; Heckman and Smith, 1999; Hyytinen et al., 2013; Loeffler, 2018; Paola and Scoppa, 2012)⁷ that emphasizes that the treatment group may experience a dip just before the treatment. In this regard, one might suspect that timber and timber product imports may have already experienced a decline prior to the implementation of the regulation, making the previously highlighted effect less likely or making it difficult to attribute to enforcement. To test this, we define a treatment variable taking 1 over 5 before the introduction of the enforcement. In addition, we drop all observations that overlap with actual years of enforcement to ensure that our variable comprises only pretreatment observations.

Second, we include time trends in the model to control potential secular trends that may characterize our dependent variable. Indeed, recent years are characterized by a series of conferences and focus on climate change and deforestation that could trigger a decline in the import of timber and timber products before enforcement reform implementation. Next, we estimate our baseline model by excluding Indonesia, which is the only country issuing FLEGT licenses through VPA with the EU, from our sample. This is because the VPA is complementary to the European Union's Timber and Timber Products Regulatory Reform (EUTR), and countries issuing FLEGT certificates that export products with a FLEGT certificate are not required to comply with EUTR due diligence. Thus, one might think that the presence of this country in our sample influences or conditions our results. To test this, we implement an additional robustness test by removing Indonesia. Finally, in our baseline specification, we did not include the Japanese regulation because it is still being implemented. We estimate our baseline model by taking this country into account.

⁷[https://www.healthcare-economist.com/2014/04/28/time-varying-difference-in-difference/#:~:text=The%20so%2Dcalled%20'Ashenfelter%20\(moving%20effect%20of%20a%20sort](https://www.healthcare-economist.com/2014/04/28/time-varying-difference-in-difference/#:~:text=The%20so%2Dcalled%20'Ashenfelter%20(moving%20effect%20of%20a%20sort)

Table 3.3: Regulations and timber and timber product trade: Alternative Specifications

	(1)	(2)	(3)	(4)
	t-5	Trend	Drop Indonesia	Including Japan
VARIABLES				
Enforcement	0.0278 (0.0430)	-0.262*** (0.0490)	-0.258*** (0.0544)	-0.233*** (0.0487)
Covariates	Yes	Yes	Yes	Yes
Observations	6,636	7,157	6,449	7,157
R-squared	0.942	0.947	0.944	0.947
Country-pair fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1. Our dependent variable is the logarithm of value of trade..

The results of the tests presented in Columns (1)-(4) of [Table 3.3](#) reveal the following four conclusions: *i*- the effect highlighted in the previous section is due to the regulation and not to a dip in the outcome variable just before the treatment since the results in Column (1) show statistically nonsignificant coefficients; *ii*- the findings remain qualitatively unchanged with the inclusion of time trends in the model (Column (2)); *iii*- removing Indonesia does not alter our baseline results (Column (3)); and *iv*- the findings show that the effect remains statistically significant when we take into account the Japanese regulations.

3.5.2 Alternative estimation methods

In this section, we use alternative methods to test the robustness of our results. We use a gravity model and the ordinary least squares (OLS) estimator. The gravity model is used to determine the value of trade between countries as a function of a number of geographical (distance), historical (colonial ties), and economic (countries' GDP, trade costs) factors. Following Anderson and Van Wincoop ([2003](#)), Our gravity model is as follows:

$$X_{ijt} = \exp[\beta_1 \text{Enforcement}_{jt} + \beta_2 Z_{it} + \beta_3 Y_{jt} + \beta_4 \varphi_{ijt} + \alpha_{ij} + \vartheta_t + \varepsilon_{ijt}] \quad (3.2)$$

Our dependent variable X_{ijt} is the value of trade from country i to j in year t . Our variable of interest Enforcement_{jt} is a dummy variable that reflects the existence, at time t (year), of

timber regulation enforced by importing country j . Z_{it} is the vector of exporter-specific variables such as GDP, forest area, poverty gap, corruption level index, and readiness index and Y_{jt} is the vector of importer-specific variables such as GDP, forest area, and readiness index. φ_{ijt} is the vector of country-pair specific variables such as the exchange rate and bilateral tariffs. We calculate a bilateral exchange rate, which is the exchange rate of the exporting countries against the importing countries in year t . α_{ij} and ϑ_t represent country-pair fixed effects and time-fixed effects, respectively. Country-pair fixed effects control for the endogeneity of trade policies and time-invariant bilateral trade costs (P. H. Egger and Nigai, 2015; Yotov et al., 2016). We use the Poisson pseudo maximum likelihood (PPML) estimator to correct for biases that may arise from heteroskedasticity problems (Silva and Tenreyro, 2006). In addition, we estimate our model with the ordinary least squares (OLS) estimator. As in our baseline model, we add other control variables to these estimates one by one and simultaneously (Columns (2)-(9)). The results are reported in Table 3.4 for the gravity model and in Table 3.5 for the OLS estimator.⁸

⁸We report the coefficients of our variable of interest. The results with all the control variables are reported in Table C.4 and Table C.5 in the Appendix

Table 3.4: Regulations and timber and timber product trade: Gravity model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PPML								
VARIABLES									
Enforcement	-0.0949*** (0.0291)	-0.0832*** (0.0304)	-0.0977*** (0.0304)	-0.0859*** (0.0285)	-0.0868*** (0.0287)	-0.0738*** (0.0281)	-0.0945*** (0.0288)	-0.0666** (0.0310)	-0.361*** (0.0864)
Observations	7,148	6,707	7,133	7,133	7,144	7,133	6,195	5,806	7,157
Country-pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Our dependent variable is the value of trade. Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (Column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariffs (Column (7)) and all the variables (Column ((8)). In Column 9, we replace the country-pair fixed effects by the country-pair gravity variables (log distance, contiguity, common language, colony ties, RTA). There may be a difference in the number of observations between estimates because we use the Stata package `ppmlhdfe` (Correia et al., 2019) for the estimates. Singleton observations are iteratively eliminated until there are no more singletons.

Table 3.5: Regulations and timber and timber products trade: OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS								
VARIABLES									
Enforcement	-0.131** (0.0555)	-0.134** (0.0560)	-0.108* (0.0570)	-0.125** (0.0552)	-0.118** (0.0560)	-0.146** (0.0569)	-0.159*** (0.0534)	-0.200*** (0.0570)	-0.299*** (0.0831)
Observations	7,148	6,707	7,133	7,133	7,144	7,133	6,195	5,806	7,157
R-squared	0.918	0.920	0.918	0.918	0.919	0.918	0.931	0.936	0.707
Country-pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Our dependent variable is the logarithm of value of trade. Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (Column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariffs (Column (7)) and all the variables (Column ((8))). In Column 9, we replace the country-pair fixed effects by the country-pair gravity variables (log distance, contiguity, common language, colony ties, RTA). There may be a difference in the number of observations between estimates because we use the Stata package `reghdfe` (Correia et al., 2019) for the estimates. Singleton observations are iteratively eliminated until there are no more singletons.

In [Table 3.4](#), we also find that the estimated coefficients associated with our variable of interest are negative and statistically significant in all columns. In other words, the implementation of timber regulations has a negative effect on timber imports from timber-producing and processing countries. Given our import country-specific variable of interest, we cannot appropriately include fixed effects to control for multilateral resistance without absorbing our variable of interest. Thus, as an additional robustness check, we approximate the multilateral resistance terms using the approach of Scott L. Baier and Jeffrey H. Bergstrand (2009) as Crivelli and Gröschl (2016), Kareem and Martínez-Zarzoso (2020) and Afesorgbor (2019)⁹. The results are reported in [Table C.6](#) in the Appendix. As in our baseline results, we find that the implementation of these timber regulations reduces trade.

In [Table 3.5](#) with the OLS estimator, we also note that the implementation of enforcement reduces trade flows of timber and timber products. Consistent with the gravity model (PPML) and OLS results, we can conclude that changing our estimation strategy does not alter our results, thus supporting our previously reported conclusions.

3.6 Heterogeneity

In this section, we conduct heterogeneity analyses. We study the impact of the implementation of timber regulations first by subsector and then by distinguishing between types of regulations.

First, we estimate our baseline model for each subsector of timber and timber products.¹⁰ The subsectors on which we run the estimates are HS44 "Wood and articles of wood; wood charcoal", HS47: Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard", HS48: "Paper and paperboard; articles of paper pulp, of paper or of paperboard" and HS94: "Furniture; bedding, mattresses, mattress supports, cushions, and similar stuffed furnishings...". The results of the estimates for each subsector are presented in [Table 3.6](#).

⁹The term multilateral resistance is based on country-pair variables: distance, common language, colonial ties, contiguity and RTA.

¹⁰For the estimates for each subsector, we divide our sample by timber and timber product subsector before aggregating to the country-year level.

Table 3.6: Regulations and timber and timber product trade: Subsectors

	(1)	(2)	(3)	(4)
	HS44	HS47	HS48	HS94
VARIABLES	Trade			
Enforcement	-0.297*** (0.0588)	-0.583** (0.272)	-0.199** (0.0939)	-0.331*** (0.0641)
Covariates	Yes	Yes	Yes	Yes
Observations	7,001	2,139	4,874	5,324
R-squared	0.915	0.819	0.916	0.950
Country-pair fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1. Our dependent variable is the logarithm of value of trade.

Regarding our variable of interest, the estimated coefficients are negative and statistically significant in all regressions. Specifically, we find a negative and statistically significant effect of timber regulations on trade. In terms of magnitude, the effects are large for HS47 pulp and paper, HS94 wood furniture, and HS44 timber and timber products but small for HS48 paper and paperboard. These results support the view that timber regulations restrict trade in all sectors, but the effect is greater for processed products such as pulp and wood furniture.

Finally, we look at the effect according to the country initiating the reform. Since our sample is composed of countries that implemented the reform at different times and sometimes on different products, we think that the effect may depend on the type of country. The results of this test are shown in [Table 3.7](#). The conclusions show that the effect is statistically significant only for the EU-USA (Column (1)) region and Australia.¹¹ This result suggests that the measures imposed by these countries restrict trade in timber and timber products.

¹¹We add the US to the EU reforms as we encounter a technical problem using the US reform separately. Based on the historical proximity, we decided to associate the US with the EU. Moreover, the EU reform is influenced by the US reform and is similar to the latter in its mode of operation.

Table 3.7: Regulations and timber and timber product trade: Type of countries

	(1)	(2)	(3)
	EU-USA	Australia	Republic of Korea
VARIABLES			
Enforcement	-0.272*** (0.0476)	-0.395** (0.197)	0.208 (0.308)
Covariates	Yes	Yes	Yes
Observations	6,734	2,058	2,049
R-squared	0.949	0.975	0.935
Country-pair fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Note: Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Our dependent variable is the logarithm of value of trade.

3.7 Discussion

Deforestation is a disease that consumes our civilization, and the phenomenon has worsened in recent years (P Combes Motel et al., 2009). According to Ritchie and Roser (2021), we have lost a third of our forests, and annually, 10 million hectares of forest, which is equal in size to Germany, Ethiopia, groups of countries such as Eastern Europe, high-income OECD countries, or the former British colonies, are cut down. Deforestation raises climatic (or global public good) and public health issues but also development issues if it is illicit. From a climate perspective, deforestation can lead to global warming (Shukla et al., 1990; Lawrence and Vandecar, 2015; Longobardi et al., 2016; Gatti et al., 2021; Balboni et al., 2022; Villanueva et al., 2023).¹² Indeed, deforestation causes 1.5 gigatons of carbon emissions per year, equivalent to the annual emissions of Russia.¹³ The climate issue also highlights a problem of equity because countries that have experienced more deforestation in recent years are mostly poor and tend to suffer the most from the effects of climate change. The other problem of deforestation is the public health problem. Indeed, with the suppression of the natural habitat of animals, there is a direct interaction between the latter and humans, causing the proliferation of some diseases that can cause a pandemic as serious as Covid-19 (Bernstein, 2020;

¹²<https://www.conserve-energy-future.com/causes-effects-solutions-illegal-logging.php>.

¹³<https://www.usaid.gov/biodiversity/illegal-logging-and-deforestation>.

Dobson et al., 2020; Salas et al., 2020). Finally, deforestation can pose a development problem through the loss of resources for the government if criminal activities such as illegal deforestation are present (Reboredo, 2013; World Bank, 2019). This financing problem is all the more crucial today in a post-Covid period characterized by pressures on public finances, international tensions, and rising interest rates to combat inflation, making borrowing more expensive and development policy financing—among others, fighting poverty and supporting social services—more challenging.

Several causes of deforestation have been listed, including illegal logging (see, for instance, Acheampong and Maryudi, 2020; Nellemann et al., 2014), which accounts for nearly half of the world's timber trade. Between August 2003 and 2004, the deforestation rate in the Amazon, the world's largest tropical forest, was the second highest ever recorded. As a result, an area of 26,130 square kilometers—around the size of Belgium—was destroyed, most of it illegally.¹⁴ For some countries, approximately 90% of exported timber comes from illegal sources (Goncalves et al., 2012). For example, in Indonesia in the 2000s, 80% of exported timber was illegal.¹⁵ To preserve the forest and combat deforestation, many reforms have been put in place by developed countries to contain one of its major causes, i.e., illegal timber and timber product trade, which comes mainly from developing countries. In this study, we analyze the effect of these reforms based on the existing reforms, i.e., the EUTR of the EU, the Lacey Act of the United States, and the reforms of Australia, Korea, and Japan. These reforms act as a sanction on the timber trade of exporting countries, forcing them to implement a monitoring mechanism to control illegal timber and thus combat deforestation and ultimately climate change. Thus, in response to this international pressure, some timber exporting countries have adopted strategies, enforcement activities, and legality requirements to combat illegal logging and thereby slow deforestation (Cashore et al., 2016). In Brazil, for example, national implementation efforts have been made to foster the conditions necessary to implement legality verification requirements, and an international commitment has been made to eradicate illegal deforestation by 2030 (Cashore et al., 2016). Our results show that these reforms reduce timber and timber product trade to the countries mentioned above. This result is all the more important, as the preservation of the forest and its biodiversity as well as the fight against the climate is an emergency.

¹⁴<https://www.greenpeace.org.au/what-we-do/protecting-forests/threats/>.

¹⁵<https://eia-international.org/forests/the-ongoing-threat-to-indonesias-legal-timber-trade/>

Given that illegal timber and timber products are hardly traceable (Castaño, 2007; Datta et al., 2022), the purpose of our findings or paper is not to verify the legality of timber. In the first instance, our study might be considered as offering insight into the effectiveness of environmental policies aimed at limiting the trade in timber and timber products and by extension deforestation. Second, and more importantly, our study results offer a methodological approach on how to study the effectiveness of these reforms by combining matching approaches such as entropy balancing with the gravity model. However, our study has some limitations, notably two methodological issues. The first lies in the measurement of illegal timber. By definition, illegal woods are untraceable and therefore difficult to detect, making their modeling difficult. To limit this problem, we draw on the literature by considering only trade in timber from countries classified as likely to engage in illegal timber and timber product trade. Therefore, given that a large share of their timber trade is illegal, we assume that a decline in their trade may be indicative of disciplinary behavior toward more legal timber and timber product trade. Second, we face an identification problem concerning the effect of the reform due to its nonrandom nature, making the evaluation of its impact vulnerable to endogeneity. Drawing on the economics literature, we combine the gravity model with the matching approach, including the entropy balancing method, to mimic a random experiment and limit this identification question.

3.8 Conclusion

The enforcement of timber trade regulations is an important measure in international trade, as it aims to promote the legal trade of timber and timber products. However, we do not know its impact on the trade of timber and timber products as a whole. This study, therefore, contributes to the literature by analyzing the impact of the implementation of the enforcement of timber trade regulations on imports of timber and timber products between enforcement countries and their trade partners, particularly the main timber-producing and processing countries that have a significant share of illegal logging. We use data on imports of enforcement countries and their partners over the period 1995 to 2019. We use a method that combines the gravity approach with a matching technique such as entropy balancing to determine the effect of the implementation of enforcement on trade. This method has several advantages, including controlling for any potential endogeneity. Our results show that

the implementation of enforcement has a negative effect on enforcement countries' imports of timber and timber products. These results are supported by alternative specifications—with the addition of additional control variables—and the use of the gravity model and the OLS estimator. Heterogeneity tests highlight that our effect may vary depending on the type of product and reform, i.e., the country that has implemented the regulation on timber and timber products.

Our study contributes to the literature by analyzing the contribution of reforms to timber and timber product trade chiefly by proposing a methodological approach that combines matching with the gravity method. By showing in the context of the enforcement that regulations can limit timber and timber product trade, it appears that regulating timber and timber product trade can limit deforestation, which remains one of the major causes of climate change and to some extent the increase in the frequency of pandemic diseases. However, given that countries can divert their timber and timber product exports to less stringent import markets, global harmonization, for example, through international organizations such as the World Trade Organization (WTO), is needed to promote the regulation of timber and timber product trade worldwide and reduce deforestation.

The Impact of Forest Management Certification on Exports in the Wood Sector: Evidence from French firm-level data

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4.1 Introduction

In light of the risks facing forests, such as deforestation, which is exacerbated by climate change, forest certification is gaining ground as a tool for sustainable forest management. Forest certification governs the trade of forest products and is a means of ensuring that trade in forest products does not compromise the sustainability and preservation of forest resources. Forest certification was born out of an awareness of the importance of forests and their services to society, the risks they face and the need to address them. Forests and their associated services, such as the production of wood and wood products, play an important role in society. Forests have influenced economic development by supporting livelihoods and sustainable growth and today provide commercial benefits to firms, governments and households (Agrawal et al., 2013). In France, the forest wood sector occupies a strategic position in the French economy. It relies on a rich and diversified forest area, growing since 1985, to reach 17.1 million hectares in 2021, or a coverage of 31% of the territory¹. In 2020, the sector contributed to approximately 1.09% of the GDP; provided approximately 394,000 direct jobs, or 12.1% of the jobs within the industrial sectors; and created more than 500 million

¹<https://www.ign.fr/reperes/la-foret-en-france-portrait-robot> (accessed on 10 January 2023)

euros of added value compared to 2016 ².

The importance of forests to the economy and society and the protection of biodiversity requires that forests be managed sustainably to preserve their various functions (Orsi et al., 2020). Forests play an important role in mitigating climate change and pollution. They absorb and store carbon dioxide from human activity in the atmosphere (Leskinen et al., 2018). Forests help protect the environment. Trees protect water sources and soils from erosion, help retain water, produce nutrients for plants and are the backbone of forest ecosystems (FAO, 1992). Forests provide habitat for a diversity of species essential to nature and human survival and promote their preservation (FAO, 2022). Against this background, forest certification has been developed as a means to promote sustainable forest management (Rametsteiner and Simula, 2003).

Forest management certification is seen as a way to benefit from the services provided by forests while protecting them from threats such as deforestation (Tritsch et al., 2020). It is a voluntary approach to sustainable development that appeared in 1989 and developed with the Rio Earth Summit. It was introduced in 1993 as a market-based response to public concerns about deforestation in the tropics and biodiversity loss (Rametsteiner and Simula, 2003). Its objective is to encourage ethical trade and to improve access to markets through economically viable, environmentally and socially beneficial management of trees, forests and related resources (Muthoo, 2012). As pointed out by Rametsteiner and Simula (2003), forest certification is an instrument for achieving different interests, involving many actors. For example, it aims to provide market access for forest owners and managers, to promote sustainable forest management and consumption patterns for governments and to inform consumers about the products bought by providing information regarding their characteristics and their environmental impacts. The certification system consists primarily of principles and criteria defined by a standard, checks on compliance with the standard, and the issuance of a third-party certificate to organizations that comply with the standards (Espinoza et al., 2012). There are different types of forest certification systems. At the international level, the two main systems are the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). The FSC was created in 1993, while the PEFC was created in 1999. Forest certification has progressed over the past decades. In 2021, PEFC certification covered approximately 325 million hectares of forest, and FSC certification cov-

²<https://vem-fb.fr/index.php/chiffres-cles/valeur-ajoutee-et-emploi> (accessed on 10 January 2023)

ered 207 million hectares³.

In France, forest certification is very prominent, with PEFC forest certification being the most widespread. Forest certification is based on the logic of developing broad-based rules for sustainable forest management and promoting the adoption of standards through the involvement of customers (Cashore and Stone, 2012).

The literature shows that forest certification can have an impact on exports. For example, Jiaojiao Chen et al. (2020) show that certification promotes a competitive advantage in the export of forest products that results from the improved green quality level of forest certification products. Forest management certification also acts as a barrier to trade by reducing the quantities exported (J. Zhang et al., 2022). Despite the existence of these studies, the analysis of the impact of forest management certification on exports remains very limited. In addition, the existing studies have limitations. They are descriptive and qualitative and lack a clear methodology for analyzing the issue. Few studies have attempted to analyze and provide evidence of the impact of forest certification on exports. The few quantitative studies that do exist perform aggregate analyses, focusing on a group of countries, which leads to inconclusive results. Evidence on the impact of forest management certification on exports at the firm level is scarce. In addition, the analyses focus primarily on the level of certification of the importing and/or exporting country without highlighting the difference between the two and whether this difference would have an impact on exports.

In this context, the objective of this paper is to address these research gaps. Our study is the first to empirically analyze the effects of PEFC forest management certification on firms' exports and, more specifically, its effects according to firm size. We use a panel of firm-level French data on exports of wood and wood products. The firm-level analysis is more refined and takes into account heterogeneity between firms. It highlights how firms' exports are affected by forest management certification depending on their size. Forest management certification is the cornerstone of all other types of certification and attests to the proper use of forests with respect to their functions and the environment. The more sustainably managed and therefore certified forests are, the more companies can ensure the traceability of their products throughout the chain of custody to guarantee the consumer the reliability of a product from sustainably managed forests. Second, another contribution lies in the struc-

³<https://www.afd.fr/en/actualites/struggle-make-forests-sustainable-how-effective-are-verification-systems>(accessed on 10 January 2023)

ture of our variable of interest. Unlike the literature that focuses on the level of certification of partner countries, we instead consider the difference in forest management certification between the exporting country and the importing or destination country. Indeed, this variable not only informs us of the difference in certification between trading partners (e.g., between France and importing countries) but also allows us to assess the effect of a higher level of forest management certification in the exporting country compared to that in the importing or destination countries on firms' exports. Finally, we use an empirical method and employ the Poisson pseudo maximum likelihood (PPML) estimator, which allows us to account for heteroscedasticity issues and control for potential bias in our analysis.

Based on the literature, the relationship between forest certification and exports can be explained as follows. Forest certification can promote exports in forest products, on the one hand, by promoting the export competitiveness of products (J. Zhang et al., 2022). On the other hand, it does so by increasing the demand for wood and wood products from sustainably managed forests by consumers who are increasingly sensitive to environmental issues (Teisl et al., 2002) and forest protection (Rametsteiner and Simula, 2003). However, forest certification has costs that can be high and burdensome (Hoang et al., 2015) and impact production (Ebeling and Yasué, 2009). It can be subject to lengthy administrative procedures. This will limit exports, especially if the importing country has a high level of forest management certification (J. Zhang et al., 2022).

The remainder of the paper is organized as follows: [section 4.2](#) presents theoretical arguments drawn from the literature. [section 4.3](#) describes PEFC certification schemes; [section 4.4](#) and [section 4.5](#) present the data and empirical framework, respectively; and [section 4.6](#) presents the results. [section 4.7](#) concludes this study.

4.2 Related literature: Theoretical arguments

In the era of climate change, environmental issues are paramount. Greenhouse gas emissions from human activity, fossil fuel production (Höök and Tang, 2013) and deforestation (Gatti et al., 2021) are among the causes of climate change. The urgency of this phenomenon has led to the implementation of adaptation practices and to the consideration of less polluting, more environmentally friendly products. In production processes, there is a growing

awareness of climate issues and the need to reduce the carbon footprint. This is materializing in the adaptation of production processes and the adoption of innovative practices that favor materials with low environmental impact, resin uptake (Cao et al., 2022), nanoindentation measurement (Cao et al., 2021), carbon nanotube (CNT) sheet (X. Wang et al., 2021). Forest certification is part of this strategy of sustainable development and environmental protection. It is a broad tool used to promote sustainable forest management, the fight against deforestation (Yamamoto and Matsumoto, 2022) and biodiversity protection (Kalonga et al., 2016). It is seen as a way to preserve ecologically important forests, promote renewable energy from forest biomass and contribute to a green economy (Muthoo, 2012). Motivations for the stakeholder adoption of forest certification are diverse and include biodiversity conservation (Gullison, 2003), forest management and system operations (Rametsteiner and Simula, 2003), improved public image (Chen et al., 2010), and financial benefits (Maraseni et al., 2017). The most common reasons mentioned in the literature are those that are market-based, including market competitiveness, increasing market share, and consumer demand (Chen et al., 2010).

Our study aims to better understand the relationship between forest certification and exports. Forest certification is considered a means of improving the export competitiveness of forest products, as it enhances product quality (Jiaojiao Chen et al., 2020). It is a market tool that can lead to changes in management practices, better fiber utilization and better harvest quality (Van Kooten et al., 2005). Moore et al. (2012) point out that forest certification encourages firms to change their forest management and environmental practices. This is reflected in the development of forest management plans, control of invasive alien species, and preservation of biological diversity. Thus, by encouraging foresters to examine the consequences of their management and adapt their practices and by promoting learning, forest certification represents a means of improving forest production and technology (Rickenbach and Overdevest, 2006). In addition, the certification system implies a transfer of technology (Yamasaki et al., 2002), which will increase the quality and the added value of exported products. In doing so, forest certification makes it possible to guarantee both the sustainable management of the forests and the valuation of the associated products on the markets (Muthoo, 2012). Forest management certification involves monitoring the value chain. The higher the share of certified forests is, the more efficient the value chain is and the greater the export competitiveness is.

Furthermore, forest certification also aims to connect environmentally and socially conscious consumers with firms in the sector (Paluš et al., 2009). Consumer sensitivity and awareness of forest protection will encourage them to increase their demand and purchase wood from sustainably managed forests (Teisl, 2003). A country with a high proportion of certified forests conveys a positive image of its commitment to forest protection and environmental friendliness. Indeed, certification acts as a signaling mechanism that informs external stakeholders, including buyers, of the compliance of forestry firms with environmental requirements (Rickenbach and Overdevest, 2006). It reduces ecological and political uncertainties by defining a transparent and controlled forest management system that takes into account the criteria and interests of different stakeholders who may have conflicting views on these issues (Overdevest, 2004).

However, the certification process involves compliance with sustainable forest management requirements and controls, which can incur costs. Indeed, before starting the certification process, it is imperative that foresters know and understand the mechanics of the certification process. This involves the cost of information on certification requirements and the operational changes needed to meet them (Haener and Luckert, 1998). Depending on planning and documentation needs, these costs can be high (Ebeling and Yasué, 2009). The certification process involves preparation costs related to data collection, organization (public consultation and participation, staff training) and monitoring (Chen et al., 2010). Obtaining certification also involves third-party audits and controls, which entail significant costs. On-site inspections, particularly for first-time certification, involve costs that include travel expenses and professional time spent on pre- and post visit activities (E. Hansen et al., 2006). Several factors, such as the type of certification, the forest, the status and operations of the management unit, and the technical capacity, influence the costs of certification (Haener and Luckert, 1998). In addition, the certification process can be lengthy and cause delays in the production and harvesting process (Elliott, 2000). This increases production costs, slows down the production process and can affect exports. These costs and delays can constitute obstacles to the adoption of certification, and therefore barriers to trade. Indeed, as environmental protection becomes an increasingly important international issue and priority, forest certification is a market-driven requirement. It is perceived as a market requirement imposed by importers, compliance with which may be difficult to achieve (Rametsteiner and Simula, 2003). As a result, certification could discriminate against stakeholders who do not

meet the requirements, making them less competitive in the market. If forest certification is increasingly developed in an importing country, it means that it values forest certification and will be more interested in importing forest products from countries where the proportion of sustainably managed and environmentally friendly forests is high (J. Zhang et al., 2022). Similarly, importing countries may want to protect their producers at the expense of exporters by imposing environmental constraints, certification requirements or the types of certification they adopt on their foreign partners. These can entail additional costs and administrative procedures that can be cumbersome and limit market access for exporters, even when they have a good level of forest certification.

The impact of certification on exports is not straightforward, and there is no consensus in the literature. To shed light on the impact of forest certification on exports, it is important to analyze this impact empirically, taking into account the heterogeneity of firms. To our knowledge, very few studies have empirically analyzed the effect of forest certification on exports, and none have conducted firm-level analysis. This study makes an important contribution to the literature on the relationship between forest certification and exports.

4.3 PEFC certification Scheme

Our study focuses on the impact of PEFC forest management certification on exports of wood and wood products. The PEFC was created in 1999 by small and family forest owners as a pan-European forest certification scheme to promote sustainable forest management through the certification and labeling of forest products (PEFC International, 2018). Forest management certification ensures that forests are managed in a way that respects the economic, social and environmental functions of forests. Forest certification has expanded to include chain-of-custody certification that ensures product traceability throughout the supply chain. Forest management is based on the PEFC's endorsement of the PEFC Council's national and regional forest certification schemes. Certification is carried out by an independent organization that performs field checks and audits to verify compliance with PEFC standards. Certification stems from a voluntary process; thus, to be certified, the forest manager or owner and related companies must contact the national PEFC office and select a certification body recognized by the PEFC within the country to organize an audit. Some forest owners are turning to group certification. Group certification brings together all forest

owners or managers wishing to obtain PEFC certification. Group certification spreads the costs among the group members and the burdens and labor time for compliance with PEFC requirements and is favorable to small forest owners.⁴

Once compliance is established, the certificate is valid for five years with annual audits. The PEFC acts as a mutual recognition system for independent national and subnational forest certification schemes and ensures that a set of specific local factors are in line with national requirements for sustainable forest management.⁵ PEFC certification has developed on a global scale. For several years, the area of certified forests in the world has been increasing. Since 2005, the PEFC-certified forest area has tripled to reach approximately 330 million hectares in 2021 (PEFC International, 2021). PEFC certification has spread widely around the world and is considered one of the leading schemes for the protection and sustainable management of forests.

4.4 Data

Our analysis considers PEFC certification and focuses on forest management certification, which is the most widely used certification and the basis for all other certifications for which data are available.⁶ This certification guarantees that the forest is managed in a sustainable way, in accordance with its environmental, social and economic functions. The data on certifications are extracted from the PEFC website.

⁴<https://pefc.org/for-business/forest-owners/how-to-get-pefc-certified> (accessed on 30 January 2023)

⁵<https://pefc.org/what-we-do/our-approach/what-is-sustainable-forest-management> (accessed on 30 January 2023)

⁶It should be noted that the availability of certification data is very limited. We also want to test the impact of firms' chain of custody certification on their exports. It is not possible to extract these data and have information on the certification history of several firms. The data available on the websites of these organizations are limited and do not allow us to have detailed and accurate information for a chain of custody analysis.

Table 4.1: The number of hectares of PEFC-certified forests in France

France	
PEFC	
Année	Certified area (ha)
2012	6,928,967
2013	6,871,741
2014	8,100,208
2015	8,034,570
2016	8,206,117
2017	8,096,117

Source: Data from the PEFC certification website.

[Table 4.1](#) presents the French forest areas certified by the PEFC. PEFC forest certification is the most widespread in France, with more than 20% of the total forest area being PEFC certified . French PEFC-certified forest areas have increased significantly between 2012 and 2014. In our analysis, we use panel data on exports of wood and wood products from French firms provided by French Customs over the 2012-2017 period.⁷ In this database, we have information on exporting firms and the partner countries for each trade flow. [Table D.1](#) in the Appendix shows the top 10 countries of destination for exports of wood and wood products by French firms.

4.5 Empirical framework

This paper empirically analyzes the effects of the difference in the level of PEFC forest management certification on firms' exports. To do so, we estimate the following equation:

$$\begin{aligned}
X_{f,j,t} = \exp[\beta_0 + \beta_1(\text{PEFC})_{j,(t-1)} + \beta_2 \log(\text{size})_{f,(t-1)} + \beta_3 \log(\text{size})_{f,(t-1)} * (\text{PEFC})_{j,(t-1)} \\
+ \beta_4 \log(\text{GDP})_{j,t} + \beta_5 \log(\text{ER})_{j,t} + \beta_6 \text{RTA}_{j,t} + \beta_7 \log(\text{forest_area})_{j,t} + \varphi_f + \vartheta_j + \varrho_t] + \varepsilon_{f,j,t}
\end{aligned}
\tag{4.1}$$

⁷These data are extracted from the Foreign Trade Statistics database of the General Directorate of Customs and Excise (DGDDI-DSECE); they are confidential and are subject to a secrecy committee.

This equation is close to the standard gravity model because it is based on the bilateral trade of French firms and their partners and includes country-specific control variables. The standard gravity model is used to predict trade between countries as a function of the size of the countries and the distances between them. The model is widely used to empirically determine the trade effects of policies, trade costs, standards (Yotov et al., 2016). The theoretical foundations of this model include the constant elasticity of substitution (CES) model (Anderson, 1979) and monopolistic competition (Krugman, 1980). Anderson and Van Wincoop (2004) develop the standard gravity model and introduce the notion of multilateral resistance. This term refers to the significance of trade costs. It is controlled by country and time fixed effects.

The indices f , j and t represent respectively firm, destination country and year respectively. Our dependent variable $X_{f,j,t}$ represents the value of the French firm's export to a destination country j at year t . $(PEFC)_{j,(t-1)}$ is our variable of interest, which is the difference between France and the partner country in terms of the share of certified forest area in the total forest area (1-year lagged). As seen in Yamamoto and Matsumoto (2022), the share of certified forest area is calculated as the ratio of the forest area certified by the PEFC to the total forest area. This indicator gives us information on the importance of forest certification in a given country. The higher the share of certified forest area is in relation to the total forest area of a country, the more interested the country is in sustainable forest management and thus in biodiversity protection and environmental preservation. We take the difference between the shares of certified forests in order to highlight the impact of the difference in terms of forest certification on the exports of firms. When our variable of interest is positive (negative), it indicates that the share of certified forest areas in the exporting country is higher (lower) than in the importing country. Thus, the more this indicator increases, the more the share of certified forests in the exporting country increases compared to that of the importing or partner country.

Furthermore, as Fiankor et al. (2020b) point out, the intensity of existing trade can influence the decision to engage in certification, including GLOBALG.A.P (G.A.P : good agricultural practice) certification of agriculture. In the case of forest certification, this would be less likely to occur because the decision to certify forests is primarily influenced by an interest in environmental and biodiversity conservation. However, to control for this potential reverse causality bias, we consider a one-year lag in our forest certification variable. This lag allows for predetermined variables to be unaffected by shocks that occur in the current period. Sim-

ilarly, a certification at time $t-1$ is exogenous to the export at time t . This strategy is frequently used in the literature (Fontagné et al., 2015).

As mentioned earlier, the objective of our study is also to determine how this impact varies with firm size. Following Curzi et al. (2020), we control for firm size lagged by one year. This is calculated as the log of the total value of a firm's exports in a given year, regardless of market destination. This indicator is considered in the literature as a good and robust measure of firm size (Fontagné and Orefice, 2018).⁸ $\log(size)_{f,(t-1)} * (PEFC)_{j,(t-1)}$ is the interaction term between the certification variable and firm size. This variable allows us to distinguish the effect of the certification according to the size of the firm.

We also include in our specification controls such as the GDP of the destination country j , namely, $\log(GDP)_{j,t}$, and a dummy variable that specifies whether the exporting country (France) and the destination country are in a regional trade agreement, namely, $RTA_{j,t}$. These data are taken from the CEPII database. Following Gupta and Kumar (2021), $\log(ER)_{j,t}$ is the exchange rate of France against that of the destination country in year t , while $\log(forest_area)_{j,t}$ is the forest area of the destination country j in year t . These data are taken from the World Bank database. $\varphi_f + \vartheta_j + \varrho t$ represent firm, destination-country and time (year) fixed effects, respectively. These fixed effects will allow us to control for the resistance term and potential omitted variable bias. The standard variables of the gravity model, namely, distance, common language and colony ties, are controlled by these fixed effects.⁹ $\varepsilon_{f,j,t}$ is the error term. Descriptive statistics for our variables are presented in the Appendix¹⁰.

We estimate our equation with the Poisson pseudo maximum likelihood (PPML) estimator. This estimator allows for zero trade flows and is robust in the presence of heteroskedasticity (Silva and Tenreyro, 2006). It allows us to estimate our equation in its multiplicative form without putting the dependent variable into logarithm form because of its log-linear objective function (Fiankor et al., 2020b).

⁸In our database of French firms, we do not have information on balance sheets or firm characteristics; thus, we use the characteristics of export-based firms.

⁹We cannot include destination-country-time fixed effects because our variable of interest varies only in the destination-country-time dimension. Our variable of interest is therefore perfectly collinear with this fixed effect.

¹⁰We do not include tariffs imposed by partner countries in our estimates. This variable contains a large number of missing values that cause us to lose more than half of our observations. In addition, because of the small variation in tariffs in this sector over time, this variable will be highly correlated with destination-country fixed effects.

4.6 Results

4.6.1 Baseline results

In this section, we present our baseline results on the impact of the difference in PEFC certification between the exporting country (France) and the importing or destination country on firms' exports over the 2013-2017 period.¹¹ To measure the difference in terms of forest management certification, we consider the difference between the share of certified forests in France and in the partner country. Table 4.2 presents the results of the estimates of the impact of PEFC certification on firms' exports. In the estimates presented in Columns (1)-(2), we do not include fixed effects; in Column (2), we additionally add as control variables the standard gravity variables, namely, the logarithm of distance, the contiguity, colony ties, and common language variables¹²; and in Column (3), we include destination-country, firm and time fixed effects. We consider the results of the estimates with fixed effects as our baseline results and comment on these results. The results without fixed effects are not very different from those including fixed effects.

We find that the coefficient associated with firm size and RTA is positive and significant in Column (3). These results are consistent with those found in the literature. As for our variables of interest, for PEFC certification, we find in Column (3) that the estimated coefficient of the variable of interest, namely, PEFC certification, is positive and significant at the level of 1%. The estimated coefficient of the interaction variable between PEFC certification and firm size is negative and significant. For example, an increase in the difference in the share of PEFC-certified forests of 0.15 is associated with an increase in the value of exports by firms of 90%¹³. This result suggests that when the share of PEFC-certified forest area in the exporting country increases relative to that in the importing countries, the firm's exports increase. This effect is weaker when the size of the firm is larger.

An increase in PEFC-certified forests in the exporting country compared to those in importing countries represents an export advantage for firms. J. Zhang et al. (2022) point out that a high level of forest certification in an importing country is a barrier to trade because the

¹¹ Given the lag structure of our specification, we lose one year (i.e. 2012).

¹² These variables are extracted from the CEPII database. We do not include these variables in our base model because they are highly correlated with destination-country fixed effects.

¹³ The percentage change in French firms' exports resulting from a 0.15 increase in the difference in the share of PEFC-certified forests is calculated as follows: $[exp(0.15 \times \text{COEFFICIENT}) - 1] \times 100 = [exp(0.15 \times 4.285) - 1] \times 100 = 90.17\%$.

more committed the importing country is to forest certification, the more likely it is that consumers in that country will prefer to buy more environmentally friendly products from certified forests rather than other products. Thus, we believe that a higher level of forest management certification in the exporting country removes this constraint and encourages greater consumer demand ¹⁴.

¹⁴To support our results, we test the impact of forest management certification in importing (destination) countries on firms' exports. As noted earlier, forest management certification is measured by the share of certified forest area in the total forest area. The results are presented in [Table D.4](#) in the Appendix. The coefficient associated with PEFC forest management certification in the importing country is significant and negative but has a smaller impact as the size of the firm increases. In other words, the higher the share of PEFC-certified forests in the importing country is, the more it hinders exports, which is consistent with the results of J. Zhang et al. (2022). Thus, the higher the share of PEFC-certified forests in the exporting country is compared to that in the importing countries, the more this constitutes an advantage and favors the exports of firms, thereby making them more competitive in markets.

Table 4.2: The impact of PEFC certification on firms' exports

	(1)	(2)	(3)
	PPML estimates		
PEFC (t-1)	5.127*** (1.082)	6.064*** (0.953)	4.285*** (0.917)
Log size (t-1)	0.769*** (0.0179)	0.795*** (0.0146)	0.174*** (0.0266)
PEFC t-1 * log size (t-1)	-0.319*** (0.0664)	-0.363*** (0.0588)	-0.269*** (0.0538)
RTA	0.957*** (0.112)	0.106 (0.0957)	0.120*** (0.0352)
Log GDP_importer	0.628*** (0.0331)	0.499*** (0.0260)	0.0161 (0.140)
Log exchange rate	0.122*** (0.0228)	-0.0378*** (0.0143)	0.162 (0.152)
Log forest_area_importer	-0.0854*** (0.0298)	-0.000162 (0.0175)	1.055 (0.797)
Log distance		-0.456*** (0.0410)	
Contiguity		0.952*** (0.0576)	
Colony ties		0.754*** (0.0998)	
Common language		0.00843 (0.122)	
Observations	271,379	270,329	266,249

Note: *** p<0.01, ** p<0.05, * p<0.1. Column (3) includes firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfe` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses are clustered by destination-country-year.

We estimate our baseline model without the interaction variable between our PEFC certification variable of interest and the firm size variable. The results are presented in Table D.3 in the Appendix. The results are very insignificant; thus, there is an interest in controlling for the interaction because the effect depends on the size of the firm.

Indeed, consumers are increasingly sensitive to the environmental cause and to the protection of biodiversity, especially with regard to climate change, which encourages them to turn to ecological and more environmentally friendly products. Forest management certifi-

cation involves all forest industry stakeholders and helps restore a public image and maintain a good reputation by communicating to the public a commitment to the environment, forest conservation and biodiversity. Forest management certification is the foundation of forest certification and is complementary to other types of certification. The more forests that are certified, the more stakeholders are engaged in certification, the more certified products there are, and the more incentive there is for firms to follow certified products from the forest through the value chain. To the extent that forest management certification promotes improved forestry practices and production, we can assume that having a high proportion of certified forests enhances the characteristics of firms' products, which are therefore more popular with consumers. This increased consumer demand for products may offset the costs associated with certification and thus increase the value of firms' exports. These results are consistent with those of Jiaojiao Chen et al. (2020) In addition, our results highlight that the positive impact of forest management certification becomes less important as firm size increases. One possible explanation is that firms use this advantage to increase the price of their products. Larger firms that have the advantage of a lower elasticity of demand (Fontagné et al., 2015) can raise their prices more; thus, although consumers are interested in the products, they cannot afford to buy them. Therefore, they may be constrained by their income if these products are more expensive than they can afford.¹⁵

4.6.2 Robustness

In the previous section, we highlight that PEFC forest management certification has a positive impact on the exports of firms. This impact is weaker as the size of the firm increases. In this section, we perform robustness analyses on our baseline results (i.e. the estimates taking into account the fixed effects). First, we change the measure of our variable of interest, namely, PEFC forest management certification. The difference in the share of certified forest area between France and the partner country is replaced by the number of hectares of certified forest area. Next, we change our estimation method and use ordinary least squares (OLS). Unlike the PPML estimator, the OLS estimator is not robust to heteroscedasticity and does not account for zero trade flows. Finally, we change the measure of our firm size variable. This new measure is the number of distinct partners that firms have per year. This measure is based on the fact that there is a positive correlation between the number of partners

¹⁵The data at our disposal do not allow us to test this price effect in a relevant way.

the firm trades with and the size of the firm (Bernard et al., 2011). The results of these estimates are presented in Table 4.3.

Table 4.3: The impact of PEFC certification on firms' exports

	(1)	(2)	(3)
	Numbers of Certified forest area	OLS	Other size
PEFC (t-1)	0.192*** (0.0275)	1.481*** (0.322)	1.438*** (0.279)
Log size (t-1)	0.214*** (0.0292)	0.0546*** (0.0101)	0.207** (0.0825)
PEFC t-1 * log size (t-1)	-0.0118*** (0.00165)	-0.103*** (0.0248)	-0.536*** (0.0725)
RTA	0.130*** (0.0361)	-0.000901 (0.0356)	0.117*** (0.0352)
Log GDP_importer	-0.0254 (0.128)	0.277*** (0.0558)	0.00904 (0.144)
Log exchange rate	0.209 (0.142)	0.102** (0.0499)	0.177 (0.154)
Log forest_area_importer	1.077 (0.799)	-0.459 (0.287)	1.003 (0.803)
Observations	266,249	266,153	266,249

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfc` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year.

We find that the firm size variable has a positive and significant coefficient in all estimates. When we change the measure of our variable of interest, namely, PEFC forest management certification (Column (1)), we find that the coefficient associated with the PEFC certification variable is positive and significant and that of the interaction variable between PEFC certification and firm size is negative and significant with a lower magnitude compared to our baseline results. Examining the results with the OLS estimator (Column (2)), similar to our baseline results, we find that the estimated coefficient of the PEFC certification variable is positive and significant. The estimated coefficient of the interaction variable between PEFC certification and firm size is negative and significant. When we change the measure of firm size (Column (3)), the coefficient of the PEFC certification variable is positive and significant and that of the interaction variable between PEFC certification and firm size is negative and significant. In sum, our results are very little sensitive to robustness analyses. An increasing share of PEFC-certified forests in the exporting country compared to that of

the partner countries favors the firms' exports. The positive effect is weaker when the size of the firm increases.

In addition, we conduct heterogeneity analyses of our results by product category, continent, and destination-country income level. These results are presented in the Appendix. We find that the effect of forest management certification is different depending on the product category considered. This is consistent with the results of Jiaojiao Chen et al. (2020), which show that the impact of forest certification varies depending on the product category considered. Analysis of heterogeneity by continent of the importing or destination country supports the argument that the more forest certification is developed in a specific area, the greater the consumer demand is for products from sustainably managed forests and the greater the exports of firms are. In addition, we also find that firm exports increase when the partner country has a high income level. The higher the income level of a country is, the more likely it is to engage in forest certification and have the infrastructure in place for sustainable forest management. Similarly, consumers will be more interested in more environmentally friendly products from sustainably managed forests. These effects become smaller as firm size increases.

Overall, our results suggest that there is an interest in deploying forest certification not only to enable sustainable forest management, but also for exports. Forest certification should be developed to take into account market developments and consumer expectations and to promote flexibility and harmonization of certification procedures among trading partners.

Our study has implications for different stakeholders. Indeed, beyond the environmental advantage that forest certification offers, it presents an advantage on the market, Governments could therefore adopt policies to promote forest certification to encourage forest producers and firms to adopt forest certification. The main barriers to the adoption of forest certification are the associated costs, which can be high, and the administrative procedures and delays, which can be long. Governments can, for example, put in place subsidy policies to help producers and firms build technical capacity, facilitate administrative procedures and thus relieve them of the costs of adopting forest certification. These policies can also take the form of market incentives such as rebates or tax exemptions for stakeholders who adopt forest certification. Export promotion agencies or programs also have a role to play in promoting forest certification. Their role is to provide assistance to firms to promote

better export performance. They can assist forest producers and firms in achieving certification, providing the necessary documentation and technical capacity. They can also provide additional guidance on the environmental requirements of markets and how certification can meet these requirements, specifying preferred practices, characteristics, etc. Managers should also participate in this promotion dynamic by reaching out to agencies and programs that meet their needs and opportunities for certification development.

4.7 Conclusion

The impact of certification on exports is an interesting issue. However, few studies have analyzed this effect. The existing literature remains descriptive and aggregated, which makes it difficult to draw conclusions. In this paper, we contribute to the literature by analyzing the impact of the difference in the level of PEFC forest management certification between an exporting country and importing or destination countries on exports at firm level. In particular, we determine how this impact differs by firm size. Our study has some advantages over the previous literature in that it accounts for firm heterogeneity and differing levels of certification across trading partners. We use a large panel of exports of wood and wood products at the level of French firms. We use an empirical method with a robust estimator, PPML.

Our results show that an increase in the share of PEFC-certified forests in the exporting country compared to that in the importing countries favors exports of wood and wood products. The effect becomes weaker as the size of the firm increases. In addition, we also find heterogeneity by product category, geographic area, and income level of destination countries.

This study has some limitations, particularly in terms of data. More detailed data on certification is not readily available, particularly on chain-of-custody certification. Similarly, firm-level data is subject to statistical confidentiality, making it difficult to obtain more detailed data on a large panel of firms. For example, we were unable to extend our analysis to chain-of-custody certification linked to forest management certification. To the extent that data are available, future research should extend the analysis to chain-of-custody certification by determining its complementarity in the impact of forest certification on exports. Similarly, with more detailed data, it would be interesting to adopt a configurational approach or

comparative qualitative analysis (CQA) to highlight the interactions and factors underlying forest certification and exports at firm level.

Conclusion

This thesis analyzes the effects of standards and regulations on international trade in wood and wood products. Generally, it highlights the different effects of these measures on trade depending on the nature of the standards, the type of product considered. This thesis is divided into four chapters. In the first chapter, we analyze the impact of SPS and TBT measures, distinguishing between technical regulations and conformity assessment procedures, on trade in the forest-wood-paper sector. We use UNCTAD's Trains database on measures implemented in individual countries. We also determine the effect of these measures according to the level of development of importing and exporting countries, and to product type. Using bilateral indicators, we highlight differences and similarities in regulatory characteristics between countries. Chapter 2 focuses on so-called restrictive SPS measures. In other words, measures that have been the subject of at least one specific trade concern within SPS committees. We analyze the impact of these measures on the value and duration of trade in wood and wood products. We describe the duration of trade using the Kaplan-Meier estimator. Chapter 3 analyzes the impact of regulations designed to promote trade in legal timber and timber products. It is based on timber regulations imposed by the United States, Australia, the Republic of Korea and members of the European Union (EU). We use a method combining the gravity approach and a matching technique such as entropy balancing to identify the effect of implementing these measures on imports of wood and wood products from wood-producing and wood-processing countries with a great share of illegal logging. Chapter 4 examines the effect of forest management certification on exports by French firms. It analyzes the effect of differences in the level of forest management certification between exporting (France) and importing countries. We determine the effect as a function of firm size.

In the first chapter, we find that trade flows increase with SPS and TBT conformity assessment procedures and TBT technical regulations. Exports from developing countries are affected negatively by conformity assessment procedures imposed by developed countries, and positively by such measures imposed by developing countries. This result can be explained in part by the fact that developed countries implement regulations more intensively than developing countries. The effect of SPS and TBT measures depends on the sub-sector under consideration. For example, paper industry products increase in the presence of TBTs. The results of the second chapter show that trade in wood and wood products is short-lived, as has been highlighted in the literature for other sectors. Restrictive SPS measures reduce the value of trade, but have no significant effect on its duration. We show in the third chapter that the implementation of timber regulations aimed at banning trade in illegally logged timber and timber products reduces the value of trade, particularly in paper and wooden furniture. The impact of these regulations varies according to the country implementing them. The effect is significant for the EU-USA region and Australia. In the last chapter, we found that the level of forest management certification plays a key market role. When the share of certified forests in the exporting country increases relative to that in destination countries, exports increase. The effect is weak as firm size increases. The effect of forest management certification on exports is not homogeneous, and varies according to the income level of destination countries, geographical area and product category.

Through its chapters, this thesis has contributed to highlighting the specific effects of standards, regulations on trade in wood and wood products. This thesis shows that the effect of these measures should not be generalized, as it is heterogeneous depending on the factor considered. Each chapter raises policy implications, such as the need for international harmonization of regulations, standards, and the deployment of forest certification worldwide.

This work can be extended to better understand the impact of standards on trade in wood and wood products. Standards remain difficult to measure, not least because of their complexity (they can take many forms), but also because of the limited data available. An alternative would be to carry out a survey to collect data. A survey would not only identify the measures in place in countries, but also the restrictive nature of these measures, in other words those that have a significant impact on stakeholders. Beyond the quantitative aspect, the data collected through the survey will enable us to identify the qualitative aspect of the impact of the measures. A second approach to extending this work is to identify

environmental regulations and standards and determine their effects on the trade in wood and wood products. With the emergence of climate change, we have noticed that climate change has many consequences, particularly for forests. Although forests are essential to the fight against climate change because of their ability to absorb and store carbon, the effects of climate change do not spare them. Forests and tree growth processes such as photosynthesis are highly dependent on climate. Consequently, an increase in temperature can alter the normal growth process of forest trees. Aware of the environmental threat or risk posed by climate change, trade policies are increasingly geared towards protecting the environment and mitigating the effects of climate change. These policies can have an impact on the harvesting and processing of wood, and therefore on the trade in wood and wood products. It would be interesting to analyze the effects of these specific trade policies and whether they promote or restrict trade.

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Appendices

Appendix of Chapter 1

Table A.1: Descriptive Statistics

Variable	Observations	Mean	Std. Dev.
SPS_ Technical Regulations	530,549	0.295	0.837
TBT_ Technical Regulations	530,549	0 .483	1.049
SPS_ conformity assessments	530,549	0.209	0.792
TBT_ conformity assessments	530,549	0.380	1.016
Imports	530,549	1445.934	23993.22
ln (1+ tariff)	530,549	0.972	1.163
Indist	530,549	8.512	0 .933
Contiguity	530,549	0.070	0.256
Common language	530,549	0.181	0.385
Colony ties	530,549	0.045	0.208
RTA	530,549	0.350	0.477
GDP	530,549	726.125	66.519

Table A.2: Coverage Ratio of SPS and TBT Technical Regulations, 2012-2015

HS2	Description	Technical regulations TBT			Technical regulations SPS		
		Affected imports (million USD)	Potentially affected im- ports (mil- lion USD)	Coverage ratio(%)	Affected imports (million USD)	Potentially affected imports (mil- lion USD)	Coverage ratio(%)
44	Wood and articles of wood; wood charcoal	159221.5	332081.9	48%	162837	332081.9	49%
45	Cork and articles of cork	1098.328	2832.36	39%	587.615	2832.36	21%
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork	2114.094	6803.479	32%	4688.85	6803.479	69%
47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard	26220.73	141682.6	18%	23215.5	141682.6	16%
48	Paper and paperboard; arti- cles of paper pulp, of paper or of paperboard	122061.3	297456.4	41%	28978.4	297456.4	10%
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans	29635.63	93889.09	31%	1658.53	93889.09	2%
94	Furniture; bedding, mat- tresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or in- cluded; illuminated signs, illuminated name-plates and the like; prefabricated buildings	113848.8	150193	76%	7656.6	150193	5%

Note: Own calculations made at the HS six-digit level and aggregated to HS two-digit level.

Table A.3: Coverage Ratio of SPS and TBT conformity assessment procedures, 2012-2015

HS2	Description	Conformity assessment procedure TBT			Conformity assessment procedure SPS		
		Affected imports (million USD)	Potentially affected imports (million USD)	Coverage ratio(%)	Affected imports (million USD)	Potentially affected imports (million USD)	Coverage ratio(%)
44	Wood and articles of wood; wood charcoal	197422	332081.9	59%	117750.7	332081.9	35%
45	Cork and articles of cork	699.282	2832.36	25%	124.0526	2832.36	4%
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork	1448.933	6803.479	21%	2843.058	6803.479	42%
47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard	91589.66	141682.6	65%	23308.21	141682.6	16%
48	Paper and paperboard; articles of paper pulp, of paper or of paperboard	53974.71	297456.4	18%	6955.081	297456.4	2%
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, type-scripts and plans	2610.002	93889.09	3%	1226.237	93889.09	1%
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated name-plates and the like; prefabricated buildings	42962.23	150193	29%	7563.159	150193	5%

Note: Own calculations made at the HS six-digit level and aggregated to HS two-digit level.

Table A.4: List of Countries

Importer
Algeria, Argentina, Australia, Austria, Bahrain, Belarus, Belgium, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Cape Verde, Chile, China, Colombia, Costa Rica, Cyprus, Czech Republic, Denmark, Ecuador, Estonia, Ethiopia(excludes Eritrea), Finland, France, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, China, Hungary, India, Ireland, Italy, Japan, Kazakhstan, Jamaica, Korea, Rep., Kyrgyz Republic, Latvia, Lebanon, Lithuania, Malta, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Niger, Oman, Pakistan, Panama, Paraguay, Peru, Poland, Portugal, Qatar, Romania, Russian Federation, Saudi Arabia, Senegal, Slovak Republic, Slovenia, Spain, Sri Lanka, Sweden, Switzerland, Tunisia, Turkey, United Arab Emirates, United Kingdom, United States, Uruguay, Zimbabwe
Exporter
Afghanistan, Albania, Algeria, Andorra, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, The, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Bouvet Island, Brazil, Brunei, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Congo, Dem. Rep., Congo, Rep., Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Estonia, Eswatini, Ethiopia(excludes Eritrea), Fiji, Finland, France, Gabon, Gambia, The, Georgia, Germany, Ghana, Greece, Greenland, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, China, Hungary, Iceland, India, Indonesia, Iran, Islamic Rep., Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Dem. Rep., Korea, Rep., Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mayotte, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Occ. Pal. Terr., Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, FR, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, Solomon Islands, Somalia, South Africa, South Sudan, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe

Table A.5: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector by country groups

Dependent variable: imports	PPML Estimates							
	Developed	Developed	Developed	Developed	Developing	Developing	Developing	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPS_ Technical Regulations	0.0378 (0.0695)				-0.0969** (0.0463)			
TBT_ Technical Regulations		0.142*** (0.0311)				0.0829*** (0.0313)		
SPS_conformity assessments			0.115** (0.0478)				0.0999** (0.0485)	
TBT_conformity assessments				0.198*** (0.0232)				0.177*** (0.0338)
ln(1+tariff)	-0.436*** (0.0513)	-0.407*** (0.0508)	-0.421*** (0.0511)	-0.237*** (0.0477)	-0.0801* (0.0483)	-0.0701 (0.0486)	-0.0680 (0.0499)	-0.0392 (0.0472)
RTA	0.00511 (0.0865)	-0.00717 (0.0889)	0.00730 (0.0872)	0.0400 (0.0840)	-0.0514 (0.0709)	-0.0534 (0.0715)	-0.0727 (0.0690)	-0.189** (0.0908)
GDP	0.0112*** (0.00212)	0.0120*** (0.00213)	0.0114*** (0.00211)	0.0129*** (0.00202)	0.00736** (0.00370)	0.00712* (0.00383)	0.00749** (0.00371)	0.00839** (0.00374)
Nbr of Observations	266,843	266,843	266,843	266,843	262,685	262,685	262,685	262,685

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-exporter, product and time fixed effects. Columns (1)-(4): Exporters-developed, Columns (5)-(8): Exporters-developing. The Stata package `ppmlhdfe` is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

Table A.6: The impact of SPS and TBT measures on trade in the Forest-Wood-Paper sector by importers'level of development

Dependent variable: imports	PPML Estimates			
	(1)	(2)	(3)	(4)
SPS_Technical Regulations	0.0668 (0.0435)			
TBT_Technical Regulations		0.119*** (0.0400)		
SPS_Conformity Assessments			0.119*** (0.0365)	
TBT_Conformity Assessments				0.206*** (0.0224)
SPS_Technical Regulations*imp_devped	-0.106 (0.0916)			
TBT_Technical Regulations*imp_devped		0.0450 (0.0520)		
SPS_Conformity Assessments*imp_devped			-0.250*** (0.0770)	
TBT_Conformity Assessments*imp_devped				-0.109* (0.0618)
ln(1+tariff)	-0.227*** (0.0390)	-0.214*** (0.0392)	-0.213*** (0.0395)	-0.116*** (0.0378)
RTA	-0.00769 (0.0498)	-0.0128 (0.0505)	-0.00573 (0.0489)	-0.0370 (0.0569)
GDP	0.0127*** (0.00188)	0.0134*** (0.00193)	0.0127*** (0.00185)	0.0129*** (0.00184)
Nbr of Observations	529,528	529,528	529,528	529,528

Note: Robust standard errors in parentheses clustered by country-pair-product.

*** p<0.01, ** p<0.05, * p<0.1. All Columns include importer-exporter, product and time fixed effects. The Stata package ppmlhdfc is used for the estimations (Correia et al., 2019). Singletons observations are dropped iteratively until no more singletons are found. Therefore, There may be a difference in the number of observations between estimates. Keeping groups of singletons in multilevel regressions with fixed effects, where fixed effects are nested in groups could lead to incorrect inferences (Correia, 2015).

Appendix of Chapter 2

Table B.1: Descriptive statistics

Variables	Observations	Mean	Std. Dev.
Trade	717,329	1236.12	33471.44
SPS	717,329	0.002	0.05
Log GDP (importer)	715,366	19.95	1.91
Log GDP (exporter)	713,911	18.41	2.1
Log distance	717,329	8.54	0.85
Contiguity	717,329	0.03	0.17
Common language	717,329	0.12	0.32
Colony ties	716,909	0.04	0.21
FTA	717,329	0.13	0.34

Table B.2: List of Countries

Importers
Austria, Belgium, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, United States
Exporters
Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Chad, Chile, China, Colombia, Comoros, Congo, Dem. Rep., Congo, Rep., Costa Rica, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Democratic People's Republic of Korea, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Greenland, Guinea, Guinea-Bissau, Guyana, Haiti, Hong Kong, China, Hungary, Iceland, India, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Rep., Kuwait, Lao PDR, Latvia, Liberia, Lithuania, Luxembourg, Macao, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Niger, Nigeria, Norway, Oman, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Vietnam, Yemen, Zambia, Zimbabwe

Table B.3: The impact of SPS measures on trade duration in wood and wood products

	Probit	Logit	Cloglog
	(1)	(2)	(3)
SPS	0.0473 (0.204)	0.138 (0.404)	0.0871 (0.260)
Duration	-0.245*** (0.00179)	-0.519*** (0.00426)	-0.455*** (0.00352)
SPS*Duration	-0.0361 (0.0384)	-0.0839 (0.0996)	-0.0624 (0.0800)
Log GDP (importer)	-0.0202*** (0.00336)	-0.0235*** (0.00592)	-0.0116*** (0.00407)
Log GDP (exporter)	-0.0297*** (0.00351)	-0.0385*** (0.00618)	-0.0202*** (0.00425)
Log distance	-0.00861 (0.00678)	-0.0495*** (0.0121)	-0.0646*** (0.00851)
Contiguity	-0.0641** (0.0286)	-0.0782 (0.0510)	-0.0455 (0.0377)
Common language	-0.0315 (0.0211)	-0.0570 (0.0369)	-0.0324 (0.0252)
Colony ties	0.0161 (0.0393)	0.0232 (0.0702)	0.0388 (0.0509)
FTA	-0.0954*** (0.0162)	-0.167*** (0.0285)	-0.124*** (0.0198)
Initial_trade	-0.00898*** (0.00225)	-0.00820** (0.00398)	0.000351 (0.00273)
ρ	3.64E-07	4.09E-07	4.76E-08
Year dummies	Yes	Yes	Yes
product dummies	Yes	Yes	Yes
Spell num. dummies	Yes	Yes	Yes
Log-Likelihood	-36899.28	-35577.371	-34458.24
Observations	140,656	140,656	140,656

Note: *** p<0.01, ** p<0.05, * p<0.1. ρ indicates the fraction of the error variance that is due to unobserved countries-product factors."A value of q equal to zero implies that the fixed effect is not correlated with any of the independent variables" (Peterson et al., 2018). In all estimates of discrete-time hazard functions, the null hypothesis of ρ equal to zero could not be rejected.

Appendix of Chapter 3

Table C.1: Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Log trade	9,857	8.036	3.290	-6.215	16.787
Enforcement	11,575	0.197	0.398	0	1
Log GDP_importer	11,510	19.375	1.903	13.559	23.788
Log GDP_exporter	11,193	18.051	2.244	14.063	23.387
Log forest_area_importer	11,050	10.388	2.963	1.253	15.914
Log (forest_area_exporter)	11,575	12.906	1.228	11.275	15.556
Readiness_importer	11,050	0.601	0.103	0.292	0.816
Readiness_exporter	11,575	0.348	0.092	0.153	0.601
Poverty_gap_exporter	11,575	10.891	14.477	0.0003	66.515
Corruption_exporter	8,925	-0.579	0.463	-1.420	0.397
Log exchange rate	11,203	3.039	4.017	-10.051	10.853
Poverty_gap_importer	10,301	0.583	1.843	0	14.820
Corruption_importer	9,618	1.219	0.857	-1.141	2.459
Vulnerability_importer	10,925	0.327	0.049	0.241	0.543
Vulnerability_exporter	11,575	0.477	0.067	0.357	0.610
Rule of law_importer	9,693	1.228	0.673	-1.084	2.125
Rule of law_exporter	8,925	-0.483	0.521	-1.619	0.579
Regulatory_quality_importer	9,618	1.238	0.594	-0.583	2.255
Regulatory_quality_exporter	8,925	-0.377	0.542	-1.399	0.799
Log distance	11,575	8.930	0.502	5.754	9.799
Contiguity	11,575	0.015	0.122	0	1
Common language	11,575	0.119	0.324	0	1
Colony ties	11,550	0.019	0.138	0	1
RTA	11,575	0.101	0.301	0	1
Log (1+tariff)	7,901	0.530	0.818	0	3.745

Table C.2: Definitions of variables and data sources

Variable	Definitions	Data Sources
Enforcement	Dummy variable equal to 1 for enforcement, 0 otherwise	Authors' calculations based on various countries' regulation websites
Trade	Value of trade	CEPII BACI (Gaulier and Zignago, 2010b)
GDP	GDP (current thousands US\$)	CEPII Gravity Database (Conte et al., 2021)
Forest area	Forest area (Sq.km)	World Bank's WDI
Poverty_gap	Poverty gap at \$ 1.90	Roser and Ortiz-Ospina, 2013
vulnerability	Climate vulnerability	University of Notre Dame Global Adaptation Index
Readiness	Climate readiness	University of Notre Dame Global Adaptation Index
Exchange rate	Official exchange rate (LCU per US\$, period average)	World Bank's WDI
Corruption	Control of corruption	Teorell et al., 2020
Rule of law	Rule of law index	Teorell et al., 2020
Regulatory quality	Regulatory quality index	Teorell et al., 2020
Distance	Distance between capitals (km)	CEPII Gravity Database (Conte et al., 2021)
Contiguity	Dummy variable equal to 1 if countries are contiguous	CEPII Gravity Database (Conte et al., 2021)
Common language	Dummy variable equal to 1 if countries share common official or primary language, 0 otherwise	CEPII Gravity Database (Conte et al., 2021)
Colony ties	Dummy variable equal to 1 if pair ever was in colonial or dependency relationship, 0 otherwise	CEPII Gravity Database (Conte et al., 2021)
RTA	Dummy variable equal to 1 if the pair currently has a Regional Trade Agreement, 0 otherwise (source: WTO)	CEPII Gravity Database (Conte et al., 2021)

Table C.3: List of countries

Importers : Australia, Austria, Belgium, Canada, China, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, India, Ireland, Israel, Italy, Japan, Hong Kong SAR, Latvia, Lithuania, Luxembourg, Malta, Macao SAR, Netherlands, New Zealand, Norway, Portugal, Republic of Korea, Russian Federation, San Marino, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United states of America
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Exporters : Brazil, China, Cameroon, Democratic Republic of the Congo, Congo, Ghana, Indonesia, Laos, Malaysia, Papua New Guinea, Thailand, Vietnam

Table C.4: Regulations and timber and timber product trade: Gravity model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PPML								
VARIABLES									
Enforcement	-0.0949*** (0.0291)	-0.0832*** (0.0304)	-0.0977*** (0.0304)	-0.0859*** (0.0285)	-0.0868*** (0.0287)	-0.0738*** (0.0281)	-0.0945*** (0.0288)	-0.0666** (0.0310)	-0.361*** (0.0864)
Log GDP_importer	0.895*** (0.0474)	0.869*** (0.0607)	0.894*** (0.0464)	0.945*** (0.0539)	0.907*** (0.0478)	0.897*** (0.0473)	0.829*** (0.0483)	0.877*** (0.0660)	1.064*** (0.0259)
Log GDP_exporter	-0.214** (0.0970)	-0.233** (0.0999)	-0.214** (0.0972)	-0.265*** (0.100)	-0.477*** (0.102)	-0.203** (0.0985)	-0.0828 (0.0996)	-0.538*** (0.114)	0.827*** (0.0371)
Log (forest_area_importer)	-0.600 (0.488)	-0.287 (0.540)	-0.591 (0.488)	-0.729 (0.472)	-0.606 (0.490)	-0.483 (0.504)	-0.583 (0.526)	-0.513 (0.610)	-0.0230 (0.0160)
Log (forest_area_exporter)	4.325*** (0.380)	4.516*** (0.392)	4.324*** (0.379)	4.231*** (0.374)	5.168*** (0.391)	4.432*** (0.409)	4.192*** (0.392)	5.054*** (0.419)	-0.207*** (0.0382)
Readiness_importer	-0.466 (0.339)	-0.622* (0.346)	-0.459 (0.332)	-0.549* (0.327)	-0.508 (0.315)	-0.599* (0.314)	-0.254 (0.371)	-0.560* (0.330)	1.831*** (0.262)
Readiness_exporter	-0.0864 (0.180)	-0.0352 (0.187)	-0.0863 (0.180)	0.0134 (0.188)	-0.422** (0.179)	-0.201 (0.201)	-0.0791 (0.183)	-0.180 (0.209)	0.702 (0.571)
Poverty_gap_exporter	-0.103*** (0.0101)	-0.0974*** (0.0102)	-0.103*** (0.0101)	-0.103*** (0.00976)	-0.106*** (0.00921)	-0.101*** (0.0105)	-0.0960*** (0.0104)	-0.101*** (0.0102)	-0.0148 (0.0119)
Corruption_exporter	-0.283*** (0.0714)	-0.297*** (0.0737)	-0.283*** (0.0715)	-0.296*** (0.0715)	-0.382*** (0.0740)	-0.352*** (0.0954)	-0.326*** (0.0720)	-0.389*** (0.102)	-0.0399 (0.124)
Log exchange rate	0.0467* (0.0269)	0.0407 (0.0274)	0.0468* (0.0270)	0.0369 (0.0264)	0.0303 (0.0259)	0.0432 (0.0275)	0.150*** (0.0526)	0.0546 (0.0503)	0.0495*** (0.00949)
Poverty_gap_importer		-0.000851 (0.0170)						0.000809 (0.0186)	
Corruption_importer			-0.00997 (0.0692)					0.0344 (0.0649)	
Vulnerability_importer				2.540* (1.490)				2.141 (1.354)	
Vulnerability_exporter				-5.302** (2.186)				-6.720*** (2.364)	
Rule of law_importer					0.0915 (0.120)			0.124 (0.124)	
Rule of law_exporter					0.626*** (0.0900)			0.740*** (0.0881)	
Regulatory_quality_importer						0.0972 (0.0733)		-0.0382 (0.0686)	
Regulatory_quality_exporter						0.116 (0.103)		-0.114 (0.107)	
Log(1+tariff)							-0.114*** (0.0290)	-0.116*** (0.0297)	
Log distance									-0.268*** (0.0514)
Contiguity									0.122 (0.0928)
Common language									0.422*** (0.125)
Colony ties									-0.319*** (0.102)
RTA									0.425*** (0.0632)
Observations	7,148	6,707	7,133	7,133	7,144	7,133	6,195	5,806	7,157
Country-pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Our dependent variable is the value of trade. Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (Column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariffs (Column (7)) and all the variables (Column (8)). In Column 9, we replace the country-pair fixed effects by the country-pair gravity variables (log distance, contiguity, common language, colony ties, RTA). There may be a difference in the number of observations between estimates because we use the Stata package `ppmlhdfc` (Correia et al., 2019) for the estimates. Singleton observations are iteratively eliminated until there are no more singletons.

Table C.5: Regulations and timber and timber product trade: OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS								
VARIABLES									
Enforcement	-0.131** (0.0555)	-0.134** (0.0560)	-0.108* (0.0570)	-0.125** (0.0552)	-0.118** (0.0560)	-0.146** (0.0569)	-0.159*** (0.0534)	-0.200*** (0.0570)	-0.299*** (0.0831)
Log GDP_importer	1.592*** (0.0721)	1.402*** (0.0836)	1.588*** (0.0726)	1.679*** (0.0765)	1.594*** (0.0732)	1.633*** (0.0733)	1.412*** (0.0775)	1.319*** (0.0911)	1.154*** (0.0152)
Log GDP_exporter	0.0248 (0.0987)	-0.0214 (0.100)	0.0211 (0.0987)	-0.0284 (0.101)	-0.128 (0.101)	0.0228 (0.0984)	0.138 (0.101)	-0.152 (0.111)	1.098*** (0.0340)
Log forest_area_importer	-1.872*** (0.320)	-2.297*** (0.318)	-1.838*** (0.320)	-1.895*** (0.320)	-1.817*** (0.321)	-2.040*** (0.323)	-1.778*** (0.337)	-2.542*** (0.335)	-0.0808*** (0.00988)
Log forest_area_exporter	8.338*** (0.344)	8.489*** (0.349)	8.302*** (0.344)	8.316*** (0.342)	8.873*** (0.356)	8.310*** (0.351)	7.693*** (0.366)	8.305*** (0.390)	-0.199*** (0.0326)
Readiness_importer	-0.445 (0.430)	0.291 (0.425)	-0.516 (0.434)	-0.402 (0.429)	-0.550 (0.449)	-0.0799 (0.442)	-0.184 (0.450)	0.511 (0.461)	-1.238*** (0.226)
Readiness_exporter	0.123 (0.252)	0.347 (0.256)	0.152 (0.251)	0.153 (0.250)	-0.0936 (0.253)	0.151 (0.264)	-0.348 (0.244)	-0.363 (0.261)	1.422*** (0.430)
Poverty_gap_exporter	0.0124 (0.00992)	0.00596 (0.00992)	0.0123 (0.00992)	0.0110 (0.00985)	0.0199** (0.00998)	0.0124 (0.0100)	0.00886 (0.0108)	0.00279 (0.0106)	0.0493*** (0.00722)
Corruption_exporter	-0.156* (0.0842)	-0.142 (0.0865)	-0.158* (0.0843)	-0.155* (0.0844)	-0.362*** (0.0878)	-0.176 (0.113)	-0.218*** (0.0828)	-0.299*** (0.112)	0.678*** (0.0842)
Log exchange rate	-0.00303 (0.0150)	0.000739 (0.0150)	-0.00193 (0.0150)	-0.00940 (0.0150)	-0.000822 (0.0149)	-0.00311 (0.0150)	0.0131 (0.0180)	0.00136 (0.0180)	0.110*** (0.00722)
Poverty_gap_importer		-0.0879*** (0.0210)						-0.0820*** (0.0215)	
Corruption_importer			0.126 (0.0860)					0.124 (0.0966)	
Vulnerability_importer				6.879*** (1.980)				7.673*** (2.058)	
Vulnerability_exporter				-3.446 (2.148)				-5.016** (2.222)	
Rule of law_importer					0.105 (0.112)			0.148 (0.131)	
Rule of law_exporter					0.832*** (0.102)			0.840*** (0.107)	
Regulatory_quality_importer						-0.255*** (0.0877)		-0.379*** (0.0954)	
Regulatory_quality_exporter						0.0289 (0.113)		-0.138 (0.114)	
Tariff							-0.199*** (0.0351)	-0.189*** (0.0369)	
Log distance									-1.371*** (0.0633)
Contiguity									-0.691*** (0.142)
Common language									0.521*** (0.0855)
Colony ties									-0.158 (0.147)
RTA									0.280*** (0.0895)
Observations	7,148	6,707	7,133	7,133	7,144	7,133	6,195	5,806	7,157
R-squared	0.918	0.920	0.918	0.918	0.919	0.918	0.931	0.936	0.707
Country-pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Our dependent variable is the logarithm of value of trade. Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariffs (Column (7)) and all the variables (Column (8)). In Column 9, we replace the country-pair fixed effects by the country-pair gravity variables (log distance, contiguity, common language, colony ties, RTA). There may be a difference in the number of observations between estimates because we use the Stata package `reghdfe` (Correia et al., 2019) for the estimates. Singleton observations are iteratively eliminated until there are no more singletons.

Table C.6: Regulations and timber and timber product trade: Gravity model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PPML							
VARIABLES								
Enforcement	-0.397*** (0.0805)	-0.456*** (0.0707)	-0.394*** (0.0802)	-0.418*** (0.0743)	-0.365*** (0.0817)	-0.373*** (0.0854)	-0.367*** (0.0789)	-0.296*** (0.0677)
Log GDP_importer	1.031*** (0.0253)	1.086*** (0.0224)	1.033*** (0.0255)	0.946*** (0.0244)	1.036*** (0.0255)	1.045*** (0.0253)	1.054*** (0.0266)	1.026*** (0.0258)
Log GDP_exporter	0.726*** (0.0415)	0.727*** (0.0342)	0.722*** (0.0406)	0.760*** (0.0401)	0.693*** (0.0415)	0.603*** (0.0452)	0.724*** (0.0415)	0.540*** (0.0441)
Log forest_area_importer	-0.0415*** (0.0148)	0.0135 (0.0137)	-0.0393*** (0.0152)	-0.0194 (0.0133)	-0.0402*** (0.0154)	-0.0337** (0.0145)	-0.0712*** (0.0152)	0.0338*** (0.0130)
Log forest_area_exporter	-0.220*** (0.0339)	-0.215*** (0.0332)	-0.218*** (0.0337)	-0.257*** (0.0346)	-0.242*** (0.0341)	-0.167*** (0.0338)	-0.217*** (0.0347)	-0.156*** (0.0390)
Readiness_importer	1.671*** (0.212)	1.986*** (0.221)	1.437*** (0.374)	3.422*** (0.242)	1.165*** (0.335)	0.624* (0.338)	2.438*** (0.263)	0.927** (0.396)
Readiness_exporter	-0.503 (0.489)	-0.775* (0.413)	-0.441 (0.479)	-1.076** (0.433)	-0.438 (0.478)	0.340 (0.493)	-0.527 (0.476)	0.408 (0.440)
Poverty_gap_exporter	0.0505*** (0.00800)	0.0390*** (0.00720)	0.0485*** (0.00836)	0.0735*** (0.00824)	0.0312*** (0.0111)	0.0194* (0.0100)	0.0640*** (0.00850)	0.0134 (0.0101)
Corruption_exporter	0.00944 (0.112)	-0.166* (0.0999)	-0.0159 (0.114)	0.0476 (0.122)	0.315* (0.179)	0.397** (0.164)	0.138 (0.117)	0.400** (0.171)
Log exchange rate	0.0139* (0.00793)	0.00249 (0.00782)	0.0116 (0.00828)	0.0831*** (0.0107)	0.00314 (0.00926)	-0.00614 (0.00820)	0.0226*** (0.00828)	0.0132 (0.0109)
Poverty_gap_importer		0.121*** (0.0145)						-0.0146 (0.0292)
Corruption_importer			0.0369 (0.0432)					-0.140 (0.144)
Vulnerability_importer				7.440*** (0.479)				8.372*** (0.963)
Vulnerability_exporter				-6.447*** (1.419)				-3.352** (1.605)
Rule of law_importer					0.0702 (0.0441)			-0.124 (0.186)
Rule of law_exporter					-0.494** (0.197)			-0.206 (0.215)
Regulatory_quality_importer						0.201*** (0.0523)		0.818*** (0.172)
Regulatory_quality_exporter						-0.734*** (0.151)		-0.811*** (0.179)
Log(1+tariff)							0.233*** (0.0387)	0.0889** (0.0451)
Observations	7,157	6,715	7,141	7,141	7,152	7,141	6,208	5,819

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Our dependent variable is the value of trade. All estimates include multilateral resistance terms approximated for variables distance, common language, colonial ties, contiguity and RTA following the method of Scott L. Baier and Jeffrey H. Bergstrand (2009) Column (1) presents our baseline results. In Columns (2)-(8), we add to the basic model one by one and simultaneously other control variables: the poverty gap of the importing countries (Column (2)), the corruption index of the importing countries (Column (3)), the vulnerability index of the importing and exporting countries (Column (4)), the rule of law index of the importing and exporting countries (Column (5)), the regulatory quality index of the importing and exporting countries (Column (6)), bilateral tariffs (Column (7)) and all the variables (Column (8)). There may be a difference in the number of observations between estimates because we use the Stata package `ppmlhdfc` (Correia et al., 2019) for the estimates. Singleton observations are iteratively eliminated until there are no more singletons.

Appendix of Chapter 4

Table D.1: Top 10 export destinations for wood and wood products of French firms (2012-2017)

Country	Share of Exports
Germany	0.18
Belgium	0.13
Spain	0.10
Italy	0.09
United Kingdom	0.07
Switzerland	0.06
United States	0.05
Netherlands	0.05
China	0.02
Poland	0.02

Source: Author’s calculation based on French Customs database

Table D.2: Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Exports	327,114	142148.5	1418457	0	1.30e+08
PEFC (t-1)	327,114	0.145	0.234	-0.688	0.342
Log size (t-1)	281,902	11.577	3.224	0	19.354
PEFC t-1 * log size (t-1)	281,902	1.586	2.986	-12.956	6.556
RTA	327,114	0.689	0.463	0	1
Log GDP_importer	322,741	19.775	1.920	12.018	23.695
Log exchange rate	324,693	-1.757	2.455	-10.533	1.097
Log forest_area_importer	319,508	10.626	2.399	0.788	15.914

Table D.3: The impact of PEFC certification on firms' exports

	Without interaction
PEFC (t-1)	-0.327* (0.172)
log size t-1	0.154*** (0.0260)
RTA	0.117*** (0.0350)
log GDP_importer	0.0206 (0.140)
Log exchange rate	0.175 (0.150)
log forest_area_importer	1.028 (0.796)
Observations	266,249

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfe` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year.

Table D.4: The impact of PEFC certification on firms' exports

	PEFC of destination-country
PEFC (t-1)	-4.292*** (0.934)
log size t-1	0.0925*** (0.0292)
PEFC t-1 * log size (t-1)	0.269*** (0.0545)
RTA	0.124*** (0.0354)
log GDP_importer	0.0111 (0.141)
Log exchange rate	0.182 (0.152)
log forest_area_importer	1.072 (0.803)
Observations	266,249

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfc` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year.

Table D.5: The impact of PEFC certification on firms' exports by product category

	(I)	(II)	(III)	(IV)	(V)
	HS44	HS47	HS48	HS49	HS94
PEFC (t-1)	3.354*** (0.890)	-2.069 (4.420)	3.318*** (1.021)	6.351*** (1.305)	4.250*** (1.586)
Log size (t-1)	0.187*** (0.0385)	0.201 (0.208)	0.141*** (0.0333)	0.229*** (0.0454)	0.0534 (0.0429)
PEFC t-1 * log size (t-1)	-0.252*** (0.0492)	-0.423*** (0.126)	-0.212*** (0.0584)	-0.393*** (0.0730)	-0.271*** (0.0955)
Observations	61,238	2,526	114,927	109,534	32,492

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdf` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year. The subsectors on which we run the estimates are: HS44 "Wood and articles of wood; wood charcoal", HS47: "Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard", HS48: "Paper and paperboard; articles of paper pulp, of paper or of paperboard", HS49: "Printed books, newspapers, pictures" and HS94: "Furniture; bedding, mattresses, mattress supports, cushions, and similar stuffed furnishings...".

Table D.6: The impact of PEFC certification on firms' exports by continent.

	(I)	(II)	(III)	(IV)
	America	Asia	Europe	Oceania
PEFC (t-1)	9.151*** (1.919)	7.044 (7.554)	2.042** (1.015)	18.69*** (7.103)
Log size (t-1)	0.155*** (0.0383)	0.393*** (0.140)	0.148*** (0.0345)	0.482*** (0.175)
PEFC t-1 * log size (t-1)	-0.659*** (0.0995)	-0.549 (0.413)	-0.150** (0.0593)	-1.156*** (0.422)
Observations	22,383	40,073	150,871	3,282

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfe` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year. We group countries by continent rather than by region according to the World Bank classification to allow for more variation in our estimates. Estimates for Africa are not presented because no variation in certifications was observed for PEFC certification.

Table D.7: The impact of PEFC certification on firms' exports by income level

	(I)	(II)	(III)
	Lower middle income	Upper middle income	High income
PEFC (t-1)	20.51 (14.40)	5.166 (6.333)	2.885*** (1.012)
Log size (t-1)	0.358** (0.149)	0.271** (0.122)	0.150*** (0.0308)
PEFC t-1 * log size (t-1)	-0.737* (0.445)	-0.342 (0.349)	-0.194*** (0.0601)
Observations	35,623	30,705	186,486

Note: *** p<0.01, ** p<0.05, * p<0.1. All columns include firm, year and destination-country fixed effects. We use the Stata package `ppmlhdfe` (Correia et al., 2019) for the estimations. There may be some difference in the number of the observations between the estimates. The singleton observations are iteratively removed until there are no more singletons. Standard errors in parentheses clustered by destination-country-year. Estimates for low-income countries are not presented because no variation in certifications was observed.

Table D.8: Summary

Research:
Forest certification and Exports
Strategy:
Emprirical Analysis with firm level data.
Findings:
A higher level of PEFC forest management certification than that of the partner country favors the firm's exports. This effect is weaker as the size of the firm increases. The effects of forest certification on exports vary according to product category, geographic area and income level of destination countries.
Suggestions:
Our results suggest that forest certification must be developed with the market in mind. For certification to be optimal, the procedures associated with it must be more flexible and less onerous. This will allow stakeholders to reap the benefits. Firms have an interest in adopting innovative and more environmentally friendly practices and technologies to best comply with the requirements. In the context of climate change, forest management goes hand in hand with pollution management, as sustainable forest management promotes the environmental functions of the forest, including pollution reduction. Similarly, pollution management practices will indirectly benefit industries by minimizing risks to forests and thereby preserving the forest resource and the services it provides.