University of Brasilia

Center for Sustainable Development

Postgraduate program in Sustainable Development

Non-Tariff Measures as environmental governance instruments for international trade: Insights from sustainable fisheries

Scarlett Queen Almeida Bispo

Master's Thesis

Brasilia

December 2024

SCARLETT QUEEN ALMEIDA BISPO

Non-Tariff Measures as environmental governance instruments for international trade: Insights from sustainable fisheries

Advisor: Dr. Frédéric Mertens

Co-Advisor: Dr. Michelle Martins

Brasilia

December 2024

ABSTRACT

International trade involves socioeconomic and ecological interactions, but these dimensions are often examined separately. As a result, the environmental impacts of international trade – such as biodiversity loss, habitat degradation, and pollution – persist without effective governance, driven by actors whose activities have far-reaching consequences on distant ecosystems. This study presents international trade as a telecoupled social-ecological system and introduces Non-Tariff Measures (NTMs) as an environmental governance instrument, aiming at guiding international trade toward more environmentally sustainable outcomes. We examine the impact of NTMs related to environmentally sustainable fisheries on trade among countries with different environmental performance levels in the fisheries sector. Results suggest that NTMs can effectively limit fisheries trade that poses significant environmental harm, while simultaneously supporting exporting countries in their efforts to improve sustainability of their fisheries sectors. This approach helps prevent the redirection of exports associated to environmentally unsustainable practices toward unregulated markets and shows that NTMs can foster more balanced and environmentally responsible relations in international trade.

Keywords: International Trade. Non-tariff Measures. Telecoupling. Environmental Governance. Fisheries

Medidas não tarifárias como instrumentos de governança ambiental para o comércio internacional: insights da pesca sustentável

RESUMO

O comércio internacional envolve interações socioeconômicas e ecológicas, mas essas dimensões são frequentemente examinadas separadamente. Como resultado, os impactos ambientais do comércio internacional – como perda de biodiversidade, degradação de habitats e poluição – persistem sem uma governança eficaz, impulsionados por atores cujas atividades têm consequências de longo alcance em ecossistemas distantes. Este estudo apresenta o comércio internacional como um sistema socioecológico teleacoplado e introduz as Medidas Não Tarifárias (MNTs) como um instrumento de governança ambiental, visando orientar o comércio internacional para resultados mais sustentáveis ambientalmente. Examinamos o impacto das MNTs relacionadas à sustentabilidade ambiental na pesca sobre o comércio entre países com diferentes níveis de desempenho ambiental no setor pesqueiro. Os resultados sugerem que as MNTs podem limitar de forma eficaz o comércio de pesca que representa danos ambientais significativos, enquanto apoiam simultaneamente os países exportadores em seus esforços para melhorar a sustentabilidade de seus setores pesqueiros. Essa abordagem ajuda a prevenir o redirecionamento de exportações associadas a práticas ambientalmente insustentáveis para mercados não regulamentados e mostra que as MNTs podem promover relações mais equilibradas e ambientalmente responsáveis no comércio internacional.

Palavras-chave: Comércio Internacional. Medidas Não Tarifárias. Teleacoplamento. Governança Ambiental. Pesca.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

CETA	EU-Canada Comprehensive Economic and Trade Agreement
CITES	Convention on International Trade in Endangered Species
ES	Ecosystems Services
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GHG	Greenhouse gases
IUU fishing	Illegal, unreported and unregulated fishing
MEAs	Multilateral Environmental Agreements
NTMs	Non-Tariff Measures
SDG	Sustainable Development Goals
TPP	Trans-Pacific Partnership Agreement
UNCTAD	United Nations Trade and Development
VSS	Voluntary Sustainability Standards
WTO	World Trade Organization

TABLE OF CONTENTS

1. INTRODUCTION

International trade enables the exchange of goods between countries to meet their societal needs and consumption demands (KASTNER; ERB; HABERL, 2015). Over time, globalization has shaped trade dynamics, fragmenting production processes across various regions and leading areas with lower production costs to specialize in certain products or components (WIEDMANN; LENZEN, 2018). International trade is associated with a range of environmental damages, including deforestation, water pollution, biodiversity loss, and other forms of degradation (GUO et al., 2021), yet the fragmentation of trade separates consumption and production geographically, making it difficult to connect environmental impacts in exporting regions with consumption patterns in distant markets (EAKIN; RUEDA; MAHANTI, 2017; WIEDMANN; LENZEN, 2018).

In this context, telecoupling theory views geographically distant socioeconomics interactions – such as the exchange of goods in international trade – and ecological interactions – such as environmental damage from production for export – as interconnected systems that must be analyzed together, rather than as isolated phenomena (LIU et al., 2013). By recognizing this multidimensional nature of international trade, which encompasses socioecological interactions, we present international trade as a telecoupled system. The telecoupling framework enables the connection between exporting and importing countries through trade flows and the environmental damages generated by this trade (CARRASCO et al., 2017; HERZBERGER et al., 2019; LIU et al., 2013, 2018).

The distance between these locations makes it difficult to connect environmental harms with their underlying causes. Complex supply chains, limited transparency, scarce data, and multiple intervening factors hinder the tracing of flows and the establishment of clear causal (CARRASCO et al., 2017; NEWIG et al., 2020). As a result, it becomes challenging to identify responsibilities or hold certain actors accountable.

Governance efforts face additional challenges. Telecoupling can be described as “ungoverned” since unintended environmental consequences often emerge beyond the reach of existing institutions (EAKIN; LEMOS; NELSON, 2014). According Newig et al., (2020) and Cotta et al. (2022), several factors complicate effective governance: i) governance actors may lack sufficient knowledge due to limited transparency in global commodity chains; ii) distant actors may hold conflicting interests, making cooperation difficult; iii) numerous actors and jurisdictions involved in telecoupled flows increase transaction costs, hampering both cooperation and the implementation of bilateral and multilateral agreement; and iv) policy fragmentation can arise from differences in sending and receiving contexts (COTTA et al., 2022; NEWIG et al., 2020).

To address these issues, we propose Non-Tariff Measures (NTMs) as instruments of environmental governance explicitly aligned with telecoupling. NTMs are mandatory regulations, excluding customs tariffs, that can influence the quantity, price, or characteristics of traded goods (MOUZAM, 2020; UNCTAD, 2018). In addition to managing trade flows, NTMs can set environmental standards through sanitary, traceability, or technical requirements, guiding producers toward more sustainable methods (BODANSKY, 2000). NTMs can be implemented more swiftly than other transnational mechanisms (ESTY, 2001), adapt to evolving (VINCENT et al., 2014b), and integrate with participatory governance approaches (HE, 2019). By enhancing traceability, NTMs can also link production and trade activities more clearly to their environmental impacts, enabling the assignment of responsibilities and supporting more coherent governance of telecoupled flows.

The fisheries sector offers a practical example. Importing countries can enforce NTMs that prohibit imports of endangered species or fish caught using destructive practices (AULIYA et al., 2024; FOSTER et al., 2019; FRIEDMAN et al., 2018; SHUKLA, 2024). Compliance with such measures can encourage exporting countries to improve their environmental indicators. For instance, after the European Union banned seafood imports from Sri Lanka due to IUU fishing, the Sri Lankan government introduced policies that improved fisheries management and reduced illegal activities (SANDARUWAN; WEERASOORIYA, 2019).

Building on this reasoning, we will empirically test whether NTMs, as governance instruments, can make fisheries trade more environmentally sustainable. This leads to the hypothesis that NTMs designed to support environmental improvements will result in better trade outcomes for countries advancing their environmental performance. To test this hypothesis, we employ a gravity model, focusing on bilateral fisheries trade flows among countries representing 95% of global imports and exports from 2012 to 2022. NTMs are collected from the TRAINS database (2024) and identified as related to environmentally sustainable fishing through the adaptation of the global concordance matrix of Kravtchenko et al., (2019). Environmental indicators that measure protection of fisheries resources, bycatch and fisheries discards reduction and the conservation of endangered species inform the categorization of exporting countries into different environmental performance levels.

By examining how NTMs influence trade flows from countries with varying environmental standards, this analysis provides insights into the capacity of NTMs to serve as environmental governance instruments in telecoupled systems. To consider NTMs effective in this role, they should encourage positive outcomes for countries improving their practices and avoid shifting trade toward regions without environmental safeguards.

This dissertation is structured in two independent but complementary articles. The first, theoretical in nature, discusses the telecoupling framework in international trade and proposes NTMs as a governance tool. The second, empirical, focuses on fisheries as a case study to test these hypotheses, using the gravity model to estimate the impact of NTMs on trade patterns relative to environmental performance. This integrated approach reframes how we view trade-environment relationships and offers insights into how NTMs may foster global cooperation on environmental matters in trade contexts.

BIBLIOGRAPHY

AULIYA, M. et al. Challenges of regulating commercial use of marine elapid snakes in the Indo-Pacific. Conservation BiologyJohn Wiley and Sons Inc, , 1 out. 2024.

BODANSKY, D. What's so bad about unilateral action to protect the environment? European Journal of International Law, v. 11, n. 2, p. 339–347, 1 jan. 2000.

CARRASCO, L. R. et al. Biodiversity conservation in a telecoupled world. Ecology and Society, Published online: Sep 14, 2017 | doi:10.5751/ES-09448-220324, v. 22, n. 3, 14 set. 2017.

COTTA, B. et al. Environmental governance in globally telecoupled systems: Mapping the terrain towards an integrated research agenda. Earth System Governance, v. 13, p. 100142, 1 ago. 2022.

EAKIN, H. C.; LEMOS, M. C.; NELSON, D. R. Differentiating capacities as a means to sustainable climate change adaptation. Global Environmental Change, v. 27, n. 1, p. 1–8, 2014.

EAKIN, H.; RUEDA, X.; MAHANTI, A. Transforming governance in telecoupled food systems. Ecology and Society, Published online: Nov 24, 2017 | doi:10.5751/ES-09831-220432, v. 22, n. 4, 24 nov. 2017.

ESTY, D. C. Bridging the Trade-Environment Divide. Journal of Economic Perspectives, v. 15, n. 3, p. 113–130, 2001.

FOSTER, S. J. et al. Global seahorse trade defies export bans under CITES action and national legislation. Marine Policy, v. 103, p. 33–41, 1 maio 2019.

FRIEDMAN, K. et al. Examining the impact of CITES listing of sharks and rays in Southeast Asian fisheries. FISH AND FISHERIES, v. 19, n. 4, p. 662–676, jul. 2018.

GUO, X. et al. Achieving Win–Win Solutions in Telecoupled Human–Land Systems. Land 2021, Vol. 10, Page 272, v. 10, n. 3, p. 272, 7 mar. 2021.

HE, J. Do unilateral trade measures really catalyze multilateral environmental agreements? International Environmental Agreements: Politics, Law and Economics, v. 19, n. 6, p. 577–593, 1 dez. 2019.

HERZBERGER, A. et al. Telecoupled Food Trade Affects Pericoupled Trade and Intracoupled Production. Sustainability 2019, Vol. 11, Page 2908, v. 11, n. 10, p. 2908, 22 maio 2019.

KASTNER, T.; ERB, K. H.; HABERL, H. Global Human Appropriation of Net Primary Production for Biomass Consumption in the European Union, 1986–2007. Journal of Industrial Ecology, v. 19, n. 5, p. 825–836, 1 out. 2015.

KRAVCHENKO, A. et al. Exploring linkages between non-tariff measures and the sustainable development goals : a global concordance matrix and application to Asia and the Pacific. 20 dez. 2019.

LIU, J. et al. Framing Sustainability in a Telecoupled World. Ecology and Society, Published online: Jun 17, 2013 | doi:10.5751/ES-05873-180226, v. 18, n. 2, 17 jun. 2013.

LIU, J. et al. Spillover systems in a telecoupled Anthropocene: typology, methods, and governance for global sustainability. Current Opinion in Environmental Sustainability, v. 33, p. 58–69, 1 ago. 2018.

MOUZAM, S. M. UNESCAP and UNCTAD, Asia-Pacific Trade and Investment Report 2019: Navigating Non-tariff Measures (NTMs) Towards Sustainable Development , United Nations Economic and Social Commission for Asia and the Pacific and United Nations Conference on Trade and Development . Journal of Asian Economic Integration, v. 2, n. 1, p. 119–122, abr. 2020.

NEWIG, J. et al. Governing global telecoupling toward environmental sustainability. Ecology and Society, Published online: Nov 19, 2020 | doi:10.5751/ES-11844-250421, v. 25, n. 4, p. 1–17, 19 nov. 2020.

SANDARUWAN, K. P. G. L.; WEERASOORIYA, S. A. Non-tariff measures and sustainable development: The case of the European Union import ban on seafood from Sri Lanka. Bangkok: [s.n.]. Disponível em: <www.econstor.eu>.

SHUKLA, A. The Future of Trade and Environment: A Roadmap for Reconciling Two Competing Goals. [s.l: s.n.]. Disponível em: <https://www.wto.org/english/>.

UNCTAD. The Unseen Impact of Non-Tariff Measures: Insights from a new database. Geneva: [s.n.]. Disponível em: <https://unctad.org/system/files/official-document/ditctab2018d2_en.pdf>. Acesso em: 4 jun. 2023.

UNCTAD. TRAINS Online. Disponível em: <https://trainsonline.unctad.org/detailedSearch>. Acesso em: 4 jun. 2023.

VINCENT, A. C. J. et al. The role of CITES in the conservation of marine fishes subject to international trade. Fish and Fisheries, v. 15, n. 4, p. 563–592, 1 dez. 2014.

WIEDMANN, T.; LENZEN, M. Environmental and social footprints of international trade. Nature Geoscience Nature Publishing Group, 1 maio 2018.

2. NON-TARIFF MEASURES TOWARDS ENVIRONMENTAL GOVERNANCE OF TELECOUPLED INTERNATIONAL TRADE

1. INTRODUCTION

International trade allows nations to meet their internal demand for certain goods, through imports from countries specialized in exporting these goods (KASTNER; ERB; HABERL, 2015). Thus, nations have the opportunity to benefit from their comparative advantages and engage in commercial exchanges that optimize the allocation of resources (SAMUELSON, 1948). This approach is based on the premise that the export of goods that are intensive in abundant resources provides advantages related to a lower relative cost of production and the maximization of economic gains, compared to other products that are intensive in other production factors (RICARDO, 1817).

Since globalization became a development policy, it has reshaped the dynamics of international trade, including the fragmentation of production processes across various geographic regions. As a result, areas with lower production costs – often due to an abundance of the production factor most intensively used in a given product – began specializing in the production and export of specific components. This approach has effectively reduced overall production costs (WIEDMANN; LENZEN, 2018).

The geographical separation of production chains has complicated environmental governance, making it increasingly challenging to link the environmental impacts generated by consumption to the various locations where different stages of production occur. (WIEDMANN; LENZEN, 2018). The dissociation between consumption and the environmental impacts of production makes it difficult for consumers to promote institutional changes in exporting regions that suffer immediate environmental damage (EAKIN; RUEDA; MAHANTI, 2017).

The telecoupling framework is a way of evaluating the socioeconomic and ecological interactions between distant locations (LIU et al., 2013), becoming an interesting approach to identifying the environmental challenges driven by international trade and the actors involved. Within the telecoupling framework, the world is conceptualized as multiple coupled social-ecological systems that interact across distances through flows, which can be either tangible (e.g. goods, organisms, people, materials) or intangible (e.g. capital, knowledge, technology).

These flows are connect sending to receiving systems and can indirectly influence other socio-ecological systems through what is known as spillover (CARRASCO et al., 2017; HERZBERGER et al., 2019; LIU et al., 2013).

We present international trade as a telecoupled system based on the premise that international trade can be conceptualized and analyzed as telecoupled socioecological systems, and explicitly acknowledges that international trade is a multidimensional process where the economic aspects of commercial relations are indissociable from their social and ecological impacts.

International trade connects exporting countries (the sending systems) to importing countries (the receiving systems) through multiple flows, and to others countries which are indirectly affected by trade activities (the spillover systems) (LIU et al., 2018). Analyzing international trade interactions within the framework of telecoupled systems, can help identify and characterize local-scale environmental impacts in exporting countries, such as deforestation, water pollution, biodiversity loss, resource depletion, soil degradation, and species invasion (GUO et al., 2021). Viewing international trade through this lens necessitates a reformulation of governance structures, shifting from a local-based approach to a flow-centered approach (LIU et al., 2018; NEWIG et al., 2019).

The negative impacts of telecoupled international trade can be reduced through the implementation of political instruments, such as international agreements and enforcement mechanisms (GUO et al., 2021). They overcome challenges related to the divergences of interests and priorities of the countries involved, creating shared rules and mechanisms transborder, which embody the flow-centered governance approach, necessary to address the shared responsibilities of consumers, producers, and affected third parties in mitigating environmental damage associated with international trade. As consequence, the environmental responsibility is shared since the extraction to consumption (EAKIN; RUEDA; MAHANTI, 2017; ELIASSON et al., 2023).

To this end, an instrument of environmental governance for international trade is proposed in which consumer countries (importers) recognize their responsibility for the unsustainable production standards of exporting countries and apply regulations that influence imported goods – Non-Tariff Measures (NTMs) – aimed at promoting environmental conservation. NTMs are any mandatory regulations, excluding customs tariffs, that can influence the quantity and prices of goods in international trade (UNCTAD, 2018). Despite this basic definition, countries can implement these regulations not only to control prices and quantities but also to shape the characteristics of goods by establishing sanitary requirements, technical standards, and certification requirements for imported products. These measures serve the public interest in the health and lives of humans, animals, or plants and the conservation of natural resources or wildlife (UNCTAD, 2019). Thus, when implemented by an importing country, NTMs can achieve legitimate environmental protection goals and alter trade dynamics by encouraging more sustainable production processes (BODANSKY, 2000).

Due to their potential to change trade dynamics, NTMs could be innovative in discouraging the import of less sustainable products or with production methods that cause damage to the environment and assume an important role in the environmental governance of international trade.

This study aims to present the telecoupled international trade approach and demonstrate how NTMs can be effective instrument for steering trade toward environmental sustainability. This approach presents an opportunity to transform the flow of goods into a catalyst for environmental preservation and efficient resource use. By incorporating considerations of socio-ecological flows into NTMs, consuming countries can influence production standards abroad, encouraging exporters to adopt sustainable practices. This not only promotes conservation efforts but also fosters global collaboration in addressing environmental challenges.

By integrating the telecoupling framework with the concept of NTMs, we contribute to the discourse on environmental governance in international trade. While previous research has examined telecoupled systems and the role of NTMs separately, no study has explicitly connected these two elements to address the environmental externalities of global trade. Our framework presents international trade as a telecoupled socio-ecological system, where economic transactions are inseparably linked to social and environmental impacts across distant regions. This perspective allows for a more comprehensive understanding of how NTMs can serve as effective governance mechanisms to promote environmental sustainability within these interconnected systems.

This study comprises four sections in addition to this introduction. The first section presents international trade as a telecoupled system that requires governance. The second section offers an overview of environmental issues within the multilateral trading system, highlighting how the main trade governance institutions address environmental concerns and the mechanisms within the system that can support environmental governance of trade. The following section discusses the governance of telecoupled international trade, emphasizing the role of NTMs as instruments for this governance within the theoretical framework of telecoupling. The study concludes with final considerations.

2. UNDERSTANDING THE TELECOUPLED INTERNATIONAL TRADE

Although international trade involves at least two countries – an importer and an exporter – its environmental damage is often associated with the country of production, even if that country is not solely responsible for the burden (INGRAM et al., 2018). The separation of environmental damage in the exporter, from the importing country complicates the attribution of responsibility to its primary beneficiary – the importing country – which gains economic benefits by acquiring goods produced elsewhere without directly bearing the associated environmental costs (WIEDMANN et al., 2015).

To comprehend the interrelationships between the consumption decisions of importing countries and the resulting environmental damage in exporting countries, it is necessary to incorporate the spatial dimension of environmental problems. Jayadevappa and Chhatre (2000) argue that interactions between trade and the environment can be analyzed by categorizing environmental issues arising from production and consumption into three spatial categories: intra-country (local), inter-country (cross-border), and global.

These spatial dimensions highlight how international trade impacts the environment and can facilitate the comprehension of how frameworks telecoupling can serve as instruments for global environmental governance. This approach guides the reader toward the article's central message: that integrated frameworks are fundamental for addressing the environmental impacts associated with international trade.

Intra-country problems occur locally and require internally implemented control measures to mitigate them. An example is the construction of dams to supply water for export-bound production, which alters river flows, aquatic biodiversity, and local communities. These challenges necessitate specific policies and actions at the national level to ensure environmental protection and the well-being of affected populations. Inter-country environmental problems arise when more than one country is responsible for the degradation of shared natural resources such as rivers, coastal seas, lakes, and common areas. In such cases, a country can affect the well-being of its neighbors, requiring solutions that often necessitate cooperation between them. Global environmental problems transcend borders and affect global well-being, such as climate change and the preservation of endangered species. These issues often require international cooperation to resolve (JAYADEVAPPA; CHHATRE, 2000).

Identifying the actors and linking them to the environmental problem is not trivial, especially considering the fragmentation of international trade and the extensive production chains involved in products (WIEDMANN; LENZEN, 2018). This complexity underscores the importance of frameworks that can effectively trace and analyze these interconnections. By employing such frameworks, we can better understand the roles and responsibilities of different actors within international trade systems, enhancing global environmental governance mechanisms. The telecoupling framework, in particular, offers reflections into these dynamics by integrating human and environmental dimensions across distances.

The telecoupling concept contributes to an integrated view of environmental problems in international trade (LIU et al., 2013). The idea has been proposed to provide an overarching explanation of socioeconomic and environmental interactions observed across long distances, related to exchanges of information, energy, and materials across multiple space-time scales (LIU et al., 2015). The telecoupling framework integrates human and environmental dimensions, such as socioeconomic interactions between human systems across distances (globalization) and environmental interactions between natural systems over long distances (teleconnections) (LIU et al., 2013, 2018), advancing these approaches to develop an integrative science in coupled human and natural systems across distances.

A key aspect of the telecoupling framework is its recognition of the multifaceted nature of international trade systems. International trade is not merely an exchange of physical goods, but encompasses multiple types of relationships and flows, including commercial relationships (physical flows of products), ecological relationships (virtual flows of ecosystem services), social and governance relationships. By considering all these interactions, the telecoupling framework enables a more comprehensive understanding of how international trade impacts both sending and receiving systems, particularly concerning social and ecological consequences in producer countries.

Geographic regions are not closed systems but open systems connected with other regions through socioeconomic and ecological interactions that form telecoupled systems (KOELLNER et al., 2019). This means that human-induced socio-ecological changes in one place produce socio-ecological effects in geographically distant places due to their interconnection through global flows (COTTA et al., 2022; FRIIS; NIELSEN, 2017).

There are five main components in the telecoupling structure: (i) systems, which are differentiated between sending, receiving, and spillover approaches; (ii) flows, which can be tangible (e.g., agricultural commodities, people, materials) or intangible (e.g., capital, knowledge, technology); (iii) agents, who can facilitate flows, such as governments, individuals, or organizations; (iv) causes that motivate these connections, such as demand from international trade or tourism; and (v) the effects, which can be diverse and on different scales, such as local deforestation in a country or the global concentration of greenhouse gases (GHG) in the atmosphere (CARLSON et al., 2018; DA SILVA et al., 2019; LIU et al., 2013, 2018).

In an international trade context, sending systems could be exemplified by Brazil exporting soybeans; the receiving system could be China importing soybeans from Brazil; and the spillover system, which experiences the indirect effects of telecoupling, could be the United States, where soybean prices fluctuate as a result of the trade between Brazil and China. In this scenario, the flow consists of the agricultural commodity soybeans, while the agents involved are the buyers and sellers from both Brazil and China. The primary cause driving this interaction is, in supposition, China's increased demand for soybeans to produce swine feed, which is required for its large-scale Chinese pork industry.

The effects of this trade dynamic are multiflows and extend beyond mere price fluctuations. For instance, the increased demand for soybeans in China can lead to the agricultural expansion of soybean cultivation in Brazil. This expansion often results in deforestation, as forests are cleared to make way for new agricultural lands. The loss of forests contributes to climate change by reducing carbon sequestration and increasing greenhouse gas emissions. Additionally, deforestation disrupts local ecosystems, leading to a loss of biodiversity and negatively impacting indigenous communities that rely on these forests for their livelihoods.

This example shows that international trade should be viewed as a telecoupled system. Recognizing trade as a network connected by socio-ecological flows enhances our understanding the environmental impacts of supply chains, especially those reliant on natural resource exploitation (DA SILVA et al., 2019). This means that, as a telecoupled system, soybean international trade involves more than just the flows of grains; it encompasses a network of economic, environmental, and social interactions that span multiple geographic regions, and trace the intricate pathways through which trade activities influence distant ecosystems and communities.

The fragmentation of supply chains brings an additional layer to the interconnections of international trade. Product supply chains can be represented by several stages, from their origin, production, processing, until reaching the final consumer or disposal (KAPLINSKY; MORRIS, 2000). During these stages, products incorporate and carry with them multiple value relationships – not only economic but also social, cultural, and environmental. These chains are dynamic and can operate from the national level to the global level. This entire process can have environmental impacts at all stages of the chain (INGRAM et al., 2018).

International trade involves the trading and incorporation of natural resources and their material and immaterial benefits, such as ecosystem services, into products used in the value chain, thereby adding environmental value to the product (INGRAM et al., 2018). This incorporation of natural resources and ecosystem services into products – such as water (LI et al., 2023), land (GUO et al., 2021), energy (CHEN et al., 2018), and nutrients (CHEN et al., 2023); and/or ecosystem services such as pollination (SILVA et al., 2021) and fishing (CARLSON et al., 2020) – are called virtual flows. Although they can result in ecological burdens on exporting countries, virtual flows are typically not accounted for in monetary transactions in international trade; only physical flows are considered (KISSINGER; REES; TIMMER, 2011).

In this scenario, the "environmental footprints" framework emerged to quantify resources used and generated by humans within a system (LIU et al., 2015). Inter-regional environmental footprints focus on the impact of regional consumption patterns on the sustainability levels of the regions supplying the goods. This includes the footprint of natural resources and ecosystem services used to facilitate international trade and the ecological burden imposed on exporting countries to satisfy consumers who are frequently unaware of the ecological costs created by their demands, especially when the exporters are developing countries (KISSINGER; REES; TIMMER, 2011).

Recognizing virtual flows and environmental footprints highlights how these flows contribute to environmental degradation and enhances our understanding of the multifaceted consequences of international trade. This connection reinforces the need to present international trade as a telecoupled system due to its multirelational and multiflow nature, encompassing commercial relationships (physical flows of food products), ecological relationships (virtual flows of ecosystem services), social relationships, and governance relationships.

Understanding how ecosystem services are embedded in goods reveals the impact of international trade on natural capital. This insight can inform policymakers and businesses about the importance of ecosystem services, potentially changing perceptions of the sustainability of global value chains (COSTANZA et al., 2017). Making virtual flows and environmental footprints visible in trade chains also aids in mapping power relations among actors, clarifying their positions and identifying who benefits or suffers environmental harm (INGRAM et al., 2018).

This awareness can enhance each country's ability to assess its external impacts and dependencies, promoting long-term sustainable development strategies (WIEDMANN; LENZEN, 2018), as interdependencies exist in both exporting and importing systems (KOELLNER et al., 2019). It also implies that importing countries recognize their responsibilities toward nations from which they receive goods containing natural resources and incorporated ecosystem services (SCHRÖTER et al., 2018).

Developing countries are more susceptible to bearing the ecological debts of developed countries, due to their dependence on the export of primary goods, such as commodities. These countries may lose important ecosystem services through international trade, which are only partially offset by their gains from export. Several examples in agri-food trade illustrate this dynamic. Mingorría et al. (2014) showed that consumption patterns and trade of palm oil in the Global North have the potential to trigger unsustainable exploitation and degradation of ecosystems in countries of the Global South. Eliasson et al. (2023) highlighted the use of phosphorus necessary in the production of Brazilian soybeans for export to the European market, which generated a non-circular displacement of phosphorus and environmental impacts for soybean fields in Brazil.

Furthermore, the import of natural resources and virtual ecosystem services – incorporated in goods exported by supplier countries – can be considered a transfer of environmental burden from receiving systems to sending systems, especially when they are developing countries (CHEN et al., 2023). Hoang and Kanemoto (2021) showed that many developed countries that achieved net forest gains internally also increased deforestation incorporated into their imports from tropical countries. Similarly, Silva et al. (2021) demonstrated that pollination services for agriculture are decreasing in exporting countries, generally developing countries, due to the increase in agricultural land dedicated to the cultivation of products dependent on biotic pollination to satisfy the growing demand from more developed countries.

Developed countries are mainly net importers[1] of impacts on biodiversity; more than 50% of their biodiversity footprint is exerted outside their territorial limits, especially in developing countries. Thus, apparent improvements in resource productivity, as well as environmental and working conditions in developed countries, are often dominated by relocations to other countries rather than being achieved solely domestically (WIEDMANN; LENZEN, 2018). This shift in resource use and environmental impact raises the need to address the accountability of consumer countries (ELIASSON et al., 2023), especially when they are developed and can contribute more financially to solving the problem.

Ensuring the environmental sustainability of telecoupled international trade through changes in modes and methods of production is as important as working to change the consumption patterns of increasingly affluent societies in large emerging and high-income economies (CARRASCO et al., 2017). Minimizing environmental damages and building synergies between international trade and environmental conservation is, therefore, a relevant topic for global development oriented toward sustainability and brings complex challenges to environmental governance (BEKOE; JALLOH, 2023; MORALES et al., 2002).

In this context, the application of international trade as telecoupled system provides ways to understand the complex interactions and its dependencies, enabling policymakers to develop more effective environmental governance strategies. By highlighting the flows and relationships in telecoupled international trade can guide actions and policies to mitigate environmental impacts and promote sustainability, aligning with the core objective of enhancing global environmental governance through intervention and enforcement mechanisms within multilateral trade system.

3. CONTEXTUALIZING THE MULTILATERAL TRADING SYSTEM AND ENVIRONMENTAL ISSUES

Since the 1970s, discussions on the role of environmental protection and sustainable development have risen in importance, largely driven by the United Nations' international agendas. These global frameworks have influenced the inclusion of social and environmental considerations in various multilateral policies, including the trade agenda under the General Agreement on Tariffs and Trade (GATT) (QUEIROZ, 2009).

[1] A country consumes more of a particular resource, product, or impact than it produces domestically, relying on imports to meet its demand.

In response to these global appeals, Article XX was incorporated into the GATT framework in 1994 as part of its multilateral trade regulation agreement. This provision, now integrated into the World Trade Organization (WTO), outlines general exceptions to trade rules. The GATT doesn't directly deal with environmental issues, but Article XX has "green provisions" that let rules be made to protect the health or life of people, animals, or plants (paragraph b) and to keep natural resources from being used up (paragraph g) (WTO, 1994).

Article XX allows countries to implement environmental regulations, provided they respect international trade rules. Such measures must not constitute arbitrary or unjustifiable discrimination between countries with similar conditions, nor serve as disguised trade restrictions (WTO, 1994). This framework grants GATT members greater autonomy to pursue environmental objectives, including restricting or banning imports that could undermine these goals (Feenstra, 2015).

Despite its importance in incorporating environmental concerns into trade, Article XX has faced criticism, particularly from exporting countries. These nations argue that differing environmental regulations act as barriers to trade, violate the principles of free trade, and harm their competitiveness (JAYADEVAPPA; CHHATRE, 2000). Promoting free trade remains a central objective of multilateral trade rules, to boost global economic development and reconstruction efforts (Queiroz, 2009). Many countries have made strides in liberalizing trade, establishing international trade as a driver of globalization (MORALES et al., 2002).

However, when free trade is analyzed solely through an economic lens, the pursuit of liberalization as an ultimate goal can lead to environmental damage. This approach often prioritizes the removal of trade barriers and the expansion of market access without adequately considering the ecological consequences. By focusing exclusively on economic growth and efficiency, trade liberalization may incentivize unsustainable production practices, overexploitation of natural resources, and the externalization of environmental costs. Such an unbalanced perspective overlooks international trade as a telecoupled system and its interconnectedness with social and ecological dynamics, exacerbating environmental degradation and undermining global sustainability efforts. In this context, environmental regulations can be perceived as efforts to mitigate the negative environmental outcomes (LENSCHOW; NEWIG; CHALLIES, 2015).

Under GATT and WTO frameworks, environmental trade regulations must meet three main conditions: (i) adherence to the general principles of free trade, (ii) compliance with other WTO agreements such as the Agreement on Sanitary and Phytosanitary Measures (SPS) and the Agreement on Technical Barriers to Trade (TBT), and (iii) alignment with the environmental exceptions under Article XX paragraphs b and g. Conditional environmental exceptions under Article XX of GATT impose strict conditions to prevent disguised protectionism, leading to legal uncertainties and potential trade retaliation that may discourage countries from adopting more ambitious environmental measures (ESTY, 2001).

Failure to meet these criteria may result in disputes raised by other WTO members, alleging non-compliance with trade obligations. In such cases, the WTO dispute resolution system may be solicited to determine whether the measure adheres to established rules. If deemed non-compliant, the Dispute Settlement Body can mandate its removal or authorize trade sanctions, such as additional tariffs or other restrictions, against the offending country (WTO, 2024).

Reconciling trade rules with environmental conservation objectives in the multilateral trade systems can be challenging, as illustrated by the outcomes of the WTO disputes concerning environmental measures had often perceived unfavorable to environmental objectives and viewed as arbitrary. One example is the "dolphin-tuna" case, where the United States imposed trade restrictions on tuna imports to address unsustainable fishing practices that threatened marine species like dolphins. Members of the European Union and Mexico, among other exporting nations, challenged these measures, claiming they were trade barriers. The WTO, until then, decided in favor of the exporters, prioritizing trade liberalization over environmental concerns (HE, 2019).

This and similar rulings have led environmental advocates to criticize the WTO for failing to adequately address the environmental consequences of trade liberalization. These outcomes highlight the WTO's limitations in reconciling trade and environmental priorities, highlighting its inability to fully engage with the complexities of the growing environmental agenda in international trade (MUNHOZ; VARGAS; VALENTE, 2023). For instance, the lack of specific regulations on pressing environmental issues, such as climate change and biodiversity conservation, limit its ability to address contemporary challenges in environmental governance (ESTY, 2001). This challenge is particularly important given the WTO's role in resolving trade-related environmental disputes, as no comparable multilateral forum exists to address these issues effectively (HE, 2019).

This criticism stems from the prevailing perception of international trade as a purely economic system, where economic objectives often overshadow environmental considerations. This reflects the idea that, in the past, the WTO primarily focused on reducing trade barriers and promoting free trade, without adequately accounting for the telecoupled systems that characterize global trade.

Nevertheless, this is changing. In March 2024, the WTO issued a landmark ruling affirming the legitimacy of the EU's Renewable Energy Directive (RED II), which imposes technical barriers on biofuel imports based on land-use and deforestation criteria to produce agricultural biofuel inputs. This decision is a recognition of the latest WTO's support for prioritizing efforts in environmental objectives over trade liberalization.

Recognizing the limitations of the WTO in dealing with environmental issues, nations have concurrently engaged in smaller-scale multilateral negotiations aimed at integrating environmental issues that directly or indirectly affect international trade. This trend is evident in the proliferation of Multilateral Environmental Agreements (MEAs), such as the Montreal Protocol, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), at least 50 MEAs include trade clauses.

For instance, the Montreal Protocol's purpose is to protect the ozone layer by restricting the production and trade of ozone-depleting substances, including chlorofluorocarbons (CFCs). While the primary objective of the agreement is environmental protection, also influences trade by imposing limitations on the export of products containing these substances, promoting technological transitions within industrial sectors (UNITED NATIONS, 2024). Similarly, CITES governs the trade of endangered species to prevent the predatory exploitation of biodiversity by enforcing restrictions on the export of products derived from protected fauna and flora, to ensure that such trade does not threaten their (BOOTH et al., 2021; KUO; VINCENT, 2018a; NIJMAN, 2015). These regulations frequently impact timber, leather and cosmetics trade, where compliance with legal requirements may result in additional costs or, in certain instances, a complete prohibition of international trade in specific items (HE, 2019).

MEAs serve the major guidelines for environmental conservation policies, but many suffer from weak compliance mechanisms, undermining the effectiveness of international environmental norms (ESTY, 2001; JINNAH; MORGERA, 2013). Furthermore, their scope may be limited, focusing on specific species or issues without addressing the broader sustainability, for example, CITES concentrates on international trade in endangered species but does not cover intranational trade or other related sustainability concerns (FRIEDMAN et al., 2018). Successful implementation of MEAs depends heavily on the commitment and capacity of signatory countries. Challenges such as resource constraints, limited institutional capacity, or lack of political will can hinder conservation efforts (JABADO; SPAET, 2017).

Although the WTO has not yet established a formal Agreement on environmental issues, countries can negotiate specific environmental provisions within Preferential Trade Agreements (PTAs). The incorporation of environmental provisions into PTAs represents a convergence between trade and sustainability objectives. These provisions are specific clauses negotiated across the countries involved in PTAs to enhance environmental protection among signatory countries. They may include specific chapters on trade and sustainable development, linking trade to domestic environmental performance and the implementation of MEAs, potentially reinforcing MEA commitments by including them as "covered agreements" and subjecting violations to trade sanctions (DISDIER; FONTAGNÉ; MIMOUNI, 2008).

The same can be implemented at regional level through Regional Trade Agreements (RTAs). Environmental provisions aim to promote environmental sustainability and harmonization of regulations among participating countries, at the same time they can be considered trade facilitators (DI UBALDO; MCGUIRE; SHIRODKAR, 2022; MARTÍNEZ-ZARZOSO; OUESLATI, 2018; YU; WANG; ZHANG, 2024). For instance, the U.S.-Peru Trade Promotion Agreement includes stringent forestry sector governance provisions, imposing obligations on Peru regarding CITES implementation, such as increasing criminal penalties for illegal timber trade and developing systems to verify the legal origin and chain of custody of CITES-listed timber species (JINNAH; MORGERA, 2013).

The Comprehensive Economic and Trade Agreement (CETA) between the European Union and Canada, for example, commits to upholding environmental protection standards, by encouraging trade and investment in environmental goods and services (USTR, 2024). Similarly, the Trans-Pacific Partnership (TPP) incorporates provisions that enforce environmental laws, protect endangered species, and combat illegal wildlife trade, ensuring that trade liberalization does not compromise environmental integrity (ANURADHA, 2017). Additionally, the United States–Mexico–Canada Agreement (USMCA) features an environmental chapter addressing air quality, marine litter, and the conservation of flora and fauna, aiming to harmonize environmental regulations among the three countries (SIELFELD OCAMPO, 2022).

The nature and degree of obligation of these provisions vary significantly among agreements. Which leads to an intersection between environmental provisions in trade agreements and Non-Tariff Measures, as mandatory environmental requirements with specific obligations can function as NTMs by imposing additional constraints on products and production processes (JINNAH; MORGERA, 2013).

Besides MEAs and PTAs, other mechanisms can potentially develop enforcement mechanisms in trade. Voluntary Sustainability Standards represent a private category of mechanisms that contribute to making trade practices more sustainable. Certification schemes like the Marine Stewardship Council (MSC) establish sustainability standards for fisheries, allowing those that meet these standards to obtain certification and market their products with the MSC label, providing consumers with assurance of sustainable sourcing (YOUNG, 2016). ISO 14001 certificate also demonstrates a company's commitment to environmental management and continuous improvement of environmental performance (DI UBALDO; MCGUIRE; SHIRODKAR, 2022). Private sector initiatives may establish their own sustainability standards for seafood supply, including supply chain traceability, prohibitions on purchasing endangered species, and support for fishery improvement projects (YOUNG, 2016).

Despite their potential benefits, VSS faces several limitations. The proliferation of ecolabels and certification schemes can create complexity and confusion for consumers and producers, making it difficult to assess the credibility and comparability of different standards. Additionally, there is a risk of "greenwashing," where unsubstantiated or misleading environmental claims are used for marketing purposes, damaging the credibility of VSS and potentially deceiving consumers. Finally, since VSS are voluntary, they rely on the willingness of companies to participate and may not be sufficient to drive systemic changes in production and consumption patterns (PRAG; LYON; RUSSILLO, 2016).

Environmentally-related NTMs can provide a more flexible mechanism to address specific environmental complexities. There is no category of environmental NTMs, but they can be considered related to the environment by their purpose. NTMs, such as import bans, quotas, licensing requirements, and certification mandates, may be employed to achieve environmental objectives. In fisheries sector, European Union employs a system of "yellow cards" and "red cards" to combat IUU fishing, issuing warnings to non-cooperating countries and potentially leading to import bans on fishery products (KIM; LIM, 2024; WONGRAK et al., 2021). The U.S. Seafood Import Monitoring Program (SIMP) requires traceability of certain imported fish products from the point of capture to entry into U.S. commerce, aiming to combat IUU fishing and promote sustainable practices (GARCÍA-ALAMINOS et al., 2021). Catch documentation schemes required by importing countries ensure that internationally traded fish products originate from legal and sustainable sources, although these measures can be controversial under WTO rules (YOUNG, 2016).

NTMs offer several advantages compared to other mechanisms. They can be implemented more rapidly than multilateral agreements that require complex and time-consuming negotiations to achieve consensus among numerous countries (ESTY, 2001). NTMs provide countries with greater autonomy in setting environmental regulations according to their priorities and specific needs, offering flexibility to adjust policies based on conservation requirements, market characteristics, and sustainable development goals (AULD, 2018). The adoption of NTMs by leading countries in environmental sustainability can also exert pressure on other nations to adopt similar measures or the creation of MEAs, encouraging harmonization of regulations and elevating sustainability standards in international trade (HE, 2019).

However, their adoption often raises concerns about arbitrariness and potential trade barriers. The diversity and complexity of NTMs make monitoring and control challenging, potentially leading to the proliferation of unjustified barriers. MEAs and PTAs, specifically, can offer a legal and political framework that supports the use of NTMs while minimizing conflicts with WTO rules (HE, 2019). Aligning these multilateral groups with NTMs is one of many possibilities to incorporate the inherent environmental responsibilities.

This analysis highlights the potential of environmentally-related NTMs as tools for advancing sustainability in international trade. By embedding these measures within frameworks such MEAs, countries can effectively balance trade liberalization with environmental conservation, addressing the international trade as telecoupled system.

4. ENVIRONMENTAL GOVERNANCE INSTRUMENTS FOR TELECOUPLED INTERNATIONAL TRADE: THE ROLE OF NON-TARIFF MEASURES

Environmental governance encompasses all interactions among societal actors aimed at coordinating, guiding, and regulating human access to the environment, managing the use of environmental resources, and mitigating their impacts. These goals are achieved through collectively binding decisions (CHALLIES; NEWIG; LENSCHOW, 2019; NEWIG et al., 2020). In this context, governance should aim to adopt measures to mitigate sustainability problems created by telecoupled systems in connected or spillover regions (LIU et al., 2018).

However, governing telecoupled systems as international trade presents challenges due to their complex interrelations, which complicates the ability of multilateral institutions to address environmental issues with specificity. At the same time, institutions with local jurisdiction face limitations in addressing telecoupled issues. Telecoupled international trade often involves interactions that extend beyond the geographic boundaries of these institutions or transcend their jurisdictions, creating governance gaps that are difficult to resolve (LENSCHOW; NEWIG; CHALLIES, 2015).

Moreover, governance actors may face knowledge deficits when attempting to regulate commodity flows due to the spatially distant nature of international trade, making it difficult to track flows and establish causality (NEWIG et al., 2020). Telecoupled systems generally involve actors with divergent interests and values, located in different socioeconomic and political contexts. Reconciling these conflicting interests and ensuring fair participation of all stakeholders in decision-making is challenging, leading to high transaction costs, hindering cooperation and the implementation of bilateral and multilateral agreements (CHALLIES; NEWIG; LENSCHOW, 2019). Additionally, telecoupled systems are dynamic and constantly evolving, requiring an adaptive and flexible governance approach (LIU et al., 2018).

Given these challenges, finding effective mechanisms for the environmental governance of telecoupled international trade is essential. Various governance arrangements exist or are being discussed at local, transnational, and global levels, including political instruments like bilateral and multilateral international treaties (GUO et al., 2021), as well as information and communication-based instruments and voluntary measures such as ISO and FSC certifications (CHALLIES; NEWIG; LENSCHOW, 2019; KISSINGER; REES; TIMMER, 2011). However, this study focuses on the contributions of Non-Tariff Measures and the framework they provide in the environmental governance of telecoupled international trade. By concentrating on NTMs, we aim to discuss how these measures can effectively address the environmental externalities associated with telecoupled international trade, offering practical solutions that enhance sustainability and regulatory compliance across global markets.

There are several reasons why NTMs are important instruments for environmental governance in telecoupled trade. Unilateral measures can be adopted more swiftly and do not require the consensus of multiple countries with differing interests, unlike treaties, MEAs, and multilateral or regional trade agreements (ESTY, 2001; HE, 2019). Furthermore, NTMs have greater reach compared to these instruments, as they can regulate all trading partners when adopted in a non-discriminatory way (BISPO et al., 2024), not just the signatories of a particular agreement or treaty.

NTMs also have greater adaptability to deal with dynamic environmental problems involving telecoupled systems and are not restricted to specific themes like MEAs such as CITES, which regulate only the international trade of some endangered species (VINCENT et al., 2014a). NTMs facilitate targeted responses to various environmental issues through the quickly adoption of other NTMs. Moreover, they can incorporate requirements for monitoring the origin and processing of imported goods through traceability measures, facilitating the identification of supply chains (BISPO et al., 2024; GARCÍA-ALAMINOS et al., 2021) and providing essential information for actors involved in the governance of telecoupled flows.

Additionally, NTMs can be more effective than voluntary instruments or private standards, such as voluntary sustainability standards. These certification schemes, typically requested by retail companies, aim to ensure a more sustainable supply chain in response to consumers' environmental concerns (MARTINS et al., 2022). However, private authority often establishes "soft" accountability and may fail to guarantee broad compliance due to the voluntary nature of VSS. The implementation of standards depends on companies' willingness to promote sustainability within their supply chains while balancing market expansion and profit maximization. Pressure from producers to reduce costs and the proliferation of new VSS can lead to audits with low rigor and quality, potentially contributing to environmental problems or failing to adequately address them (MOSER; LEIPOLD, 2021).

It is also important to note that NTMs present synergies and integration with other governance instruments such as treaties, MEAs, and trade agreements with environmental provisions. NTMs can be adopted by leveraging treaties and MEAs, establishing import criteria based on these mechanisms (HE, 2019). For example, several NTMs prohibit the entry of endangered species based on CITES or require certificates for illegal fishing based on the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) (UNCTAD, 2024), potentially filling regulatory gaps of these instruments and increasing enforcement due to their compulsory nature (HE, 2019). Furthermore, environmental provisions in trade agreements, when mandatory for trade effectiveness, can also be considered Non-Tariff Measures (DISDIER; FONTAGNÉ; MIMOUNI, 2008).

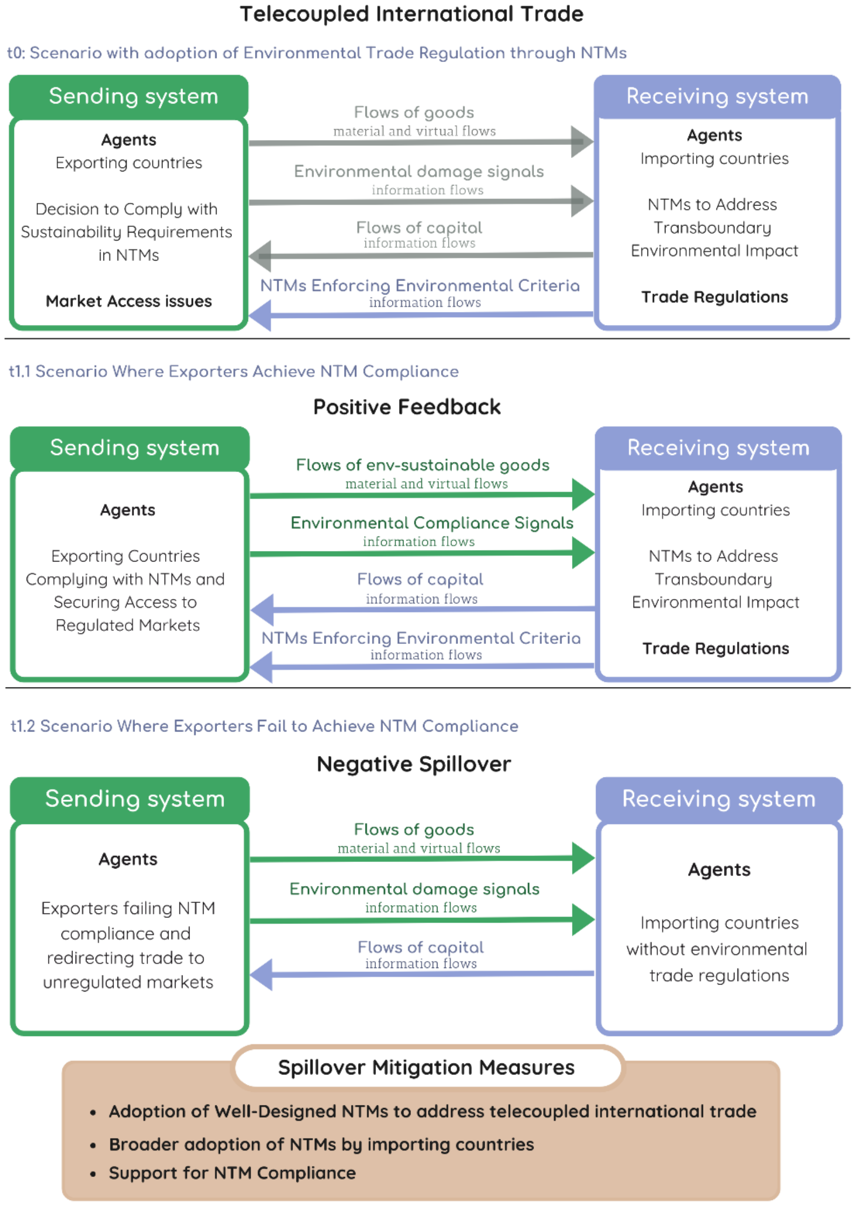
NTMs are at the forefront of measures related to trade and the environment and have increasing potential to address environmental problems (MOUZAM, 2020). NTMs such as the EU regulation to prevent imports of products linked to deforestation, in response to forest degradation and climate change, represent pioneering environmental measures involving international trade (NONNENBERG et al., 2024a). NTMs such the EU deforestation-free regulation and the Carbon Border Adjustment Mechanism (CBAM) can encourage the creation of MEAs and treaties to address these issues more broadly and participatively in international trade.

NTMs are relevant to the environmental governance of telecoupled international trade because also represent a significant step toward sharing responsibilities for environmental damages. Importing countries, as the main beneficiaries of products whose production may cause environmental harm, communicate the recognition of these damages resulting from their demand in distant locations or even globally. Besides being a relevant flow of information for the actors involved (sending and spillover systems). Mandatory import requirements, can drive significant changes in production practices to meet environmental requirements. The adoption of environmental NTMs by importing countries stimulate changes in environmental management from production to export in exporting countries (FANG; ASCHE, 2021; KIM; LIM, 2024; SANDARUWAN; WEERASOORIYA, 2019; WONGRAK et al., 2021). Due to this characteristic, it is feasible to assign responsibilities for addressing environmental side effects between the sending and receiving systems of telecoupled international trade (KOELLNER et al., 2019).

In the governance of telecoupled systems, NTMs can fit into what Koellner et al. (2019) call governance responding to telecoupling, it is used to address its negative externalities (EAKIN; RUEDA; MAHANTI, 2017; NEWIG et al., 2019). This perspective deals with environmental governance that recognizes telecoupling and seeks to reduce or avoid environmental problems created by this system. This type of governance can be related to flow-centered governance (COTTA et al., 2022), which emphasizes that governance actions in one location must consider their externalities in other nearby and distant locations, bearing in mind the recognition that there are feedbacks between sectors within one place, between places, and between scales that are often ignored because they are often difficult to detect (GUO et al., 2021).

Countries may adopt NTMs under pressure from their citizens and as a result of environmental risk assessments conducted by governments. Producers, in turn, respond by implementing practices to comply with NTM requirements, often resulting in better environmental management and promoting environmentally sustainable in international trade (DA SILVA et al., 2019; LEONIDOU; KATSIKEAS; MORGAN, 2013). On the other hand, if the requirements of NTMs are poorly designed, they may lead to trade flow diversion associated with environmental damage to unregulated countries, thereby undermining NTM ability to make trade more environmentally sustainable, as shown in Figure 1.

Figure 1 - Non-tariff Measures in Telecoupled International Trade



Source: Author's elaboration.

Figure 1 illustrates how Non-Tariff Measures (NTMs) function as instruments of environmental governance in telecoupled international trade. The diagram shows sending systems (exporting countries) on the left, receiving systems (importing countries) on the right, and the socio-ecological flows of international trade between them. The illustration is divided into two periods, t0 and t1, with t1 branching into two distinct outcomes: Positive Feedback and Negative Spillovers.

In the t0 scenario, the adoption of environmental trade regulations through NTMs is depicted. Gray arrows represent the trade behavior before NTMs were implemented. Exporting countries send goods that incorporate both material and virtual flows to importing countries together with environmental damage signals as information flows. In return, importing countries send flows of capital to represent the purchase of goods.

Recognizing the environmental damage signals, importing countries decide to regulate their imports using NTMs to address transboundary environmental impacts. They send information flows back to the exporting countries, enforcing environmental requirements. Exporting countries must then decide whether to comply with sustainability requirements in NTMs to maintain market access.

The subsequent scenario, t1.1 or Positive Feedback, illustrates the effectiveness of NTMs as environmental governance instruments for telecoupled international trade. Exporting countries now send environmentally sustainable goods by meeting the environmental requirements of the NTMs. Importing countries proceed with the trade by sending capital flows. This scenario suggests that NTMs have helped improve environmental management in exporting countries, making the flow of goods environmentally sustainable and reducing the environmental impact of international trade.

An example of this positive outcome is provided by Sandaruwan and Weerasooriya (2019), who studied the European Union's adoption of an import prohibition NTM on seafood products from Sri Lanka in 2015. The ban addressed concerns over IUU fishing. Their findings revealed that changes made in Sri Lanka's fisheries management to comply with the NTMs improved environmental practices. Sri Lanka developed an Action Plan against IUU Fishing, strengthened monitoring and control, increased transparency to combat illegal fishing, established verification and certification procedures, and provided regular reports on fishing activities. This NTM had a similar effect in Thailand. Initially, it caused a significant negative impact on the Thai fishing industry, leading to a decline in exports to the EU. In response, Thailand implemented comprehensive reforms in its fishing legislation and practices to address IUU fishing. These reforms resulted in improvements in fish stock conservation and working conditions within the sector. Consequently, in 2019, the NTM was lifted for Thailand in recognition of the progress achieved by the country (WONGRAK et al., 2021).

Furthermore, the Figure 1 shows importing country implemented the NTM by recognizing the environmental impact of its imports, sharing responsibility for previously caused environmental damage. This action reduces the likelihood of shifting environmental burdens onto the exporting country, a problem highlighted by Wiedmann et al. (2018; 2015).

Conversely, the t1.2 scenario, termed Negative Spillover, illustrates challenges faced by NTMs as governance instruments in telecoupled trade. NTMs require careful and assertive design that accounts for their potential repercussions in the affected countries. Poorly conceived NTMs risk being overly stringent or serving purely protectionist purposes (MUNHOZ; VARGAS; VALENTE, 2023). This can lead to the diversion of unsustainable trade flows from non-compliant exporting countries to unregulated markets (NONNENBERG et al., 2024a), perpetuating trade practices associated with environmental harm. This dynamic resembles the 'Pollution Haven' hypothesis, which postulates that in the context of trade liberalization, pollution-intensive industries tend to relocate their production to countries with lenient environmental regulations, rather than adhering to stricter environmental standards in their home country (COPELAND; TAYLOR, 1994).

In the context of environmental governance of telecoupled international trade, overly stringent NTMs can shift the "Pollution Haven" from the production sites – the point of origin of environmentally harmful goods – to the importing countries that either lack environmental regulations or impose lenient standards on their imports. These countries become the new destination for accommodating "pollution", which, in this case, refers to environmentally unsustainable exports. In this scenario, NTMs lose their effectiveness as tools of environmental governance, failing to promote more environmentally sustainable trade practices.

To address these challenges, Figure 1 includes Spillover Mitigation Measures. The first mitigation measure involves ensuring the adoption of well-designed NTMs to regulate telecoupled international trade. Well-designed NTMs, in addition to preventing the diversion of unsustainable trade to unregulated markets, can create incentives for innovation in environmentally sustainable production and enhance the competitiveness of these trade flows. This aligns with the 'Porter Hypothesis' as argued by Porter and van der Linde (1995).

The potential of well-designed NTMs can be strengthened by the second mitigation measure: the broader adoption of NTMs by more importing countries. As more countries recognize the environmental impacts of their imports and implement NTMs to mitigate damage, the environmental governance effect becomes increasingly robust. This is particularly important for large importers, who have significant influence over markets (FANG; ASCHE, 2021).

Conversely, if NTMs are adopted only by countries with limited market power, there may be insufficient incentives for exporters to meet the environmental requirements. Thus, for exporting countries, the potential loss of access to key trading partners may outweigh the costs of achieving NTM compliance. (GARCÍA-ALAMINOS et al., 2021).

The final mitigation measure is Support for NTM Compliance. Achieving compliance often involves substantial costs, requiring exporting countries to evaluate the opportunity cost of maintaining access to regulated markets (BISPO et al., 2024). Cost-related challenges are particularly pronounced for developing countries, which frequently lack the financial and technical capacity to meet stringent market demands (DISDIER; FONTAGNÉ; MIMOUNI, 2008; JAFFEE; HENSON, 2004). Limited financial resources also restrict investments in technologies and production methods that could mitigate environmental harm associated with export-oriented production (LAGO, 2013; NONNENBERG et al., 2024b). Santeramo and Lamonaca (2022) highlight that the costs of NTMs are particularly burdensome for developing countries due to variations in available technologies and the challenges of adapting to international standards. Additionally, these nations often have more lenient domestic legislation, widening the regulatory gap and resulting in higher compliance costs compared to developed countries (BOOTH et al., 2020).

Sustainable development financing can drive structural changes that bridge the regulatory gap between national legislation and NTM requirements. It can also support investments in environmentally sustainable production technologies (MARTINS et al., 2024), thereby reducing the costs associated with NTMs and promoting the supply of such products. Technology transfer, investment in research and development, and technical support can enhance technical capacity and improve environmental indicators, reducing additional compliance costs (NONNENBERG et al., 2024b).

In such cases, additional measures such as Aid for Trade (AfT) are relevants. AfT is an initiative aimed at helping developing countries participate in international trade by addressing supply-side constraints and trade-related infrastructure challenges (LEE; PARK, 2018). AfT has proven effective in boosting exports and reducing trade costs in developing countries (CALÌ; TE VELDE, 2011) and can be utilized to support these nations in achieving compliance with environmental NTMs. Moon and Lee (2020) conducted a case study on Korea's AfT initiative for Bolivia, concluding that AfT contributed significantly to Bolivia's compliance with NTMs related to Technical Barriers to Trade. The initiative was aligned with broader structural policies and converged with Bolivia's Sustainable Development Goals 8, 9, and 17 (MOON; LEE, 2020).

While the acknowledgment by importing countries of environmental damage caused beyond their borders is a significant step, it is insufficient for sharing the responsibilities of environmental impact. Simply adopting NTMs without considering potential negative repercussions does not address the complex socio-ecological interactions of international trade. NTMs will only serve their governance purpose if exporting countries can comply with the requirements. Otherwise, it may merely allow importing countries to appear responsible without enacting real change, while exporting countries continue practices detrimental to environmental sustainability driven by other imports.

Recognizing the role of NTMs as an instrument of environmental governance of telecoupled international trade brings these additional layers to the discussions. NTMs alone, as well as other governance instruments, do not solve telecoupled environmental problems, but demonstrate enormous potential in promoting sustainable practices and fostering collaboration between importing and exporting countries. NTMs can help reduce the environmental impacts associated with global trade. For NTMs to fulfill this role, it is essential to support exporting countries, especially developing nations, in overcoming compliance challenges. Through cooperative efforts, capacity building, and broader adoption of well-designed environmental regulations, NTMs can contribute to more environmentally sustainable international trade practices.

5. CONCLUSIONS

International trade is often governed through socioeconomic interactions, with the multilateral system frequently prioritizing free trade decisions even when these come at an environmental cost. However, international trade should be understood as a telecoupled system involving complex socioecological interactions that pose significant environmental governance challenges. Issues such as deforestation, biodiversity loss, and greenhouse gas emissions are driven by trade practices, particularly affecting exporting countries that often shoulder the environmental burdens of importers.

Existing governance arrangements face limitations due to the lack of specificity in multilateral institutions and large treaties, the transboundary nature of the problems, and instruments that are either highly specific and rigid, such as MEAs, or voluntary and “soft” like VSS. Against this backdrop, the present study aimed to evaluate the potential of Non-Tariff Measures as environmental governance instruments capable of addressing the challenges posed by telecoupled international trade. NTMs offer advantages in terms of adaptability, flexibility, prompt responses, enforcement capacity, and the sharing of responsibilities between importers and exporters.

The findings show that NTMs can generate both positive feedback and negative spillovers. On the positive side, well-designed NTMs can make trade flows more environmentally sustainable when exporting countries comply with the environmental requirements imposed by importers. Conversely, poorly designed, overly stringent, or purely protectionist NTMs may allow harmful practices to continue through trade diversion to unregulated importers— creating pollution havens receptors. Thus, NTMs must be developed with careful consideration of the intensified socioecological interactions in a telecoupled context. This includes measures to mitigate negative spillovers, such as expanding the adoption of well-conceived NTMs to limit trade diversion and providing support for compliance in countries with insufficient financial or technical capacity.

By framing trade as a telecoupled system and highlighting NTMs as potential environmental governance tools, this study contributes to the literature on environmental governance in telecoupled systems. It introduces NTMs as instrument for making international trade more environmentally sustainable, bringing new insights into the trade-environment nexus. The results can guide policymakers in designing NTMs with an understanding of their interconnected repercussions.

Future research could further examine NTMs as governance instruments by exploring additional dimensions, such as their effects on importing countries or integrating NTMs within broader governance arrangements. Empirical models could help address existing gaps in the literature on telecoupled system governance, offering a more comprehensive understanding of how trade measures can influence environmental outcomes.

BIBLIOGRAPHY

ANURADHA, R. V. WTO to the TPP: Evolution of Environmental Provisions in Trade Agreements. Economics, Law, and Institutions in Asia Pacific, p. 241–253, 2017.

AULD, K. Trade measures to prevent illegal fishing and the WTO: An analysis of the settled faroe islands dispute. World Trade Review, v. 17, n. 4, p. 665–692, 1 out. 2018.

BEKOE, W.; JALLOH, T. Assessing the Economic Implications of Free Trade on Environmental Quality: Empirical Evidence from Africa. Environmental and Resource Economics, v. 84, n. 1, p. 19–36, 1 jan. 2023.

BISPO, S. Q. A. et al. DA FAZENDA AO MUNDO: COMO A RASTREABILIDADE AFETA O COMÉRCIO INTERNACIONAL DO AGRONEGÓCIO? Texto para Discussão, 2024.

BODANSKY, D. What's so bad about unilateral action to protect the environment? European Journal of International Law, v. 11, n. 2, p. 339–347, 1 jan. 2000.

BOOTH, H. et al. Assessing the impact of regulations on the use and trade of wildlife: An operational framework, with a case study on manta rays. Global Ecology and Conservation, v. 22, 1 jun. 2020.

BOOTH, H. et al. Estimating economic losses to small-scale fishers from shark conservation: A hedonic price analysis. CONSERVATION SCIENCE AND PRACTICE, v. 3, n. 9, set. 2021.

CALÌ, M.; TE VELDE, D. W. Does Aid for Trade Really Improve Trade Performance? World Development, v. 39, n. 5, p. 725–740, maio 2011.

CARLSON, A. K. et al. Toward Rigorous Telecoupling Causal Attribution: A Systematic Review and Typology. Sustainability 2018, Vol. 10, Page 4426, v. 10, n. 12, p. 4426, 27 nov. 2018.

CARLSON, A. K. et al. Global Marine Fishing across Space and Time. Sustainability 2020, Vol. 12, Page 4714, v. 12, n. 11, p. 4714, 9 jun. 2020.

CARRASCO, L. R. et al. Biodiversity conservation in a telecoupled world. Ecology and Society, Published online: Sep 14, 2017 | doi:10.5751/ES-09448-220324, v. 22, n. 3, 14 set. 2017.

CHALLIES, E.; NEWIG, J.; LENSCHOW, A. Governance for Sustainability in Telecoupled Systems. Telecoupling, p. 177–197, 2019.

CHEN, B. et al. Global energy flows embodied in international trade: A combination of environmentally extended input–output analysis and complex network analysis. Applied Energy, v. 210, p. 98–107, 15 jan. 2018.

CHEN, X. et al. Physical and virtual nutrient flows in global telecoupled agricultural trade networks. Nature communications, v. 14, n. 1, p. 2391, 1 dez. 2023.

COPELAND, B. R.; TAYLOR, M. S. North-South Trade and the Environment. The Quarterly Journal of Economics, v. 109, n. 3, p. 755–787, 1 ago. 1994.

COSTANZA, R. et al. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services, v. 28, p. 1–16, 1 dez. 2017.

COTTA, B. et al. Environmental governance in globally telecoupled systems: Mapping the terrain towards an integrated research agenda. Earth System Governance, v. 13, p. 100142, 1 ago. 2022.

DA SILVA, R. F. B. et al. Eco-certification protocols as mechanisms to foster sustainable environmental practices in telecoupled systems. Forest Policy and Economics, v. 105, p. 52–63, 1 ago. 2019.

DI UBALDO, M.; MCGUIRE, S.; SHIRODKAR, V. Voluntary programs and emissions revisited: What is the effect of EU trade agreements with environmental provisions? Journal of International Business Policy, v. 5, n. 4, p. 467–489, 1 dez. 2022.

DISDIER, A. C.; FONTAGNÉ, L.; MIMOUNI, M. The impact of regulations on agricultural trade: Evidence from the SPS and TBT agreements. American Journal of Agricultural Economics, v. 90, n. 2, p. 336–350, maio 2008.

EAKIN, H.; RUEDA, X.; MAHANTI, A. Transforming governance in telecoupled food systems. Ecology and Society, Published online: Nov 24, 2017 | doi:10.5751/ES-09831-220432, v. 22, n. 4, 24 nov. 2017.

ELIASSON, K. et al. A spatially explicit approach to assessing commodity-driven fertilizer use and its impact on biodiversity. Journal of Cleaner Production, v. 382, p. 135195, 1 jan. 2023.

ESTY, D. C. Bridging the Trade-Environment Divide. Journal of Economic Perspectives, v. 15, n. 3, p. 113–130, 2001.

FANG, Y.; ASCHE, F. Can US import regulations reduce IUU fishing and improve production practices in aquaculture? ECOLOGICAL ECONOMICS, v. 187, set. 2021.

FRIEDMAN, K. et al. Examining the impact of CITES listing of sharks and rays in Southeast Asian fisheries. FISH AND FISHERIES, v. 19, n. 4, p. 662–676, jul. 2018.

FRIIS, C.; NIELSEN, J. Ø. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. Sustainability 2017, Vol. 9, Page 974, v. 9, n. 6, p. 974, 7 jun. 2017.

GARCÍA-ALAMINOS, Á. et al. Reassembling social defragmented responsibilities: the indecent labour footprint of US multinationals overseas. Economic Systems Research, v. 33, n. 4, p. 536–554, 2021.

GUO, X. et al. Achieving Win–Win Solutions in Telecoupled Human–Land Systems. Land 2021, Vol. 10, Page 272, v. 10, n. 3, p. 272, 7 mar. 2021.

HE, J. Do unilateral trade measures really catalyze multilateral environmental agreements? International Environmental Agreements: Politics, Law and Economics, v. 19, n. 6, p. 577–593, 1 dez. 2019.

HERZBERGER, A. et al. Telecoupled Food Trade Affects Pericoupled Trade and Intracoupled Production. Sustainability 2019, Vol. 11, Page 2908, v. 11, n. 10, p. 2908, 22 maio 2019.

HOANG, N. T.; KANEMOTO, K. Mapping the deforestation footprint of nations reveals growing threat to tropical forests. Nature Ecology and Evolution, v. 5, n. 6, p. 845–853, 1 jun. 2021.

INGRAM, V. et al. Governance Options to Enhance Ecosystem Services in Cocoa, Soy, Tropical Timber and Palm Oil Value Chains. Environmental Management, v. 62, n. 1, p. 128–142, 1 jul. 2018.

JABADO, R. W.; SPAET, J. L. Y. Elasmobranch fisheries in the Arabian Seas Region: Characteristics, trade and management. FISH AND FISHERIES, v. 18, n. 6, p. 1096–1118, nov. 2017.

JAFFEE, S.; HENSON, S. Standards and Agro-Food Exports from Developing Countries: Rebalancing the Debate. [s.l: s.n.]. Disponível em: <http://econ.worldbank.org.>.

JAYADEVAPPA, R.; CHHATRE, S. International trade and environmental quality: a surveyEcological Economics. [s.l: s.n.]. Disponível em: <www.elsevier.com/locate/ecolecon>.

JINNAH, S.; MORGERA, E. Environmental provisions in american and EU free trade agreements: A preliminary comparison and research agenda. Review of European, Comparative and International Environmental Law, v. 22, n. 3, p. 324–339, 2013.

KAPLINSKY, R.; MORRIS, M. How do South African firms respond to trade policy reform? Chapters, p. 193–221, 2000.

KASTNER, T.; ERB, K. H.; HABERL, H. Global Human Appropriation of Net Primary Production for Biomass Consumption in the European Union, 1986–2007. Journal of Industrial Ecology, v. 19, n. 5, p. 825–836, 1 out. 2015.

KIM, D. E.; LIM, S. S. Economic impacts of the European Union carding system on global fish trade. MARINE POLICY, v. 165, jul. 2024.

KISSINGER, M.; REES, W. E.; TIMMER, V. Interregional sustainability: governance and policy in an ecologically interdependent world. Environmental Science & Policy, v. 14, n. 8, p. 965–976, 1 dez. 2011.

KOELLNER, T. et al. Guidance for assessing interregional ecosystem service flows. Ecological Indicators, v. 105, p. 92–106, 1 out. 2019.

KUO, T. C.; VINCENT, A. Assessing the changes in international trade of marine fishes under CITES regulations – A case study of seahorses. Marine Policy, v. 88, p. 48–57, 1 fev. 2018.

LAGO, A. A. C. DO. Conferências de Desenvolvimento Sustentável. Brasília: [s.n.]. Disponível em: <http://funag.gov.br/loja/download/1047-conferencias-de-desenvolvimento-sustentavel.pdf>. Acesso em: 31 maio. 2023.

LEE, H.; PARK, M. Aid for trade, labor market flexibility with implication for Korea. Journal of Korea Trade, v. 22, n. 2, p. 121–142, 2 jul. 2018.

LENSCHOW, A.; NEWIG, J.; CHALLIES, E. Globalization's limits to the environmental state? Integrating telecoupling into global environmental governance. https://doi.org/10.1080/09644016.2015.1074384, v. 25, n. 1, p. 136–159, 2 jan. 2015.

LEONIDOU, C. N.; KATSIKEAS, C. S.; MORGAN, N. A. "Greening" the marketing mix: Do firms do it and does it pay off? Journal of the Academy of Marketing Science, v. 41, n. 2, p. 151–170, 1 mar. 2013.

LI, J. et al. Telecoupling China's City-Level Water Withdrawal with Distant Consumption. Environmental Science and Technology, v. 57, n. 10, p. 4332–4341, 14 mar. 2023.

LIU, J. et al. Framing Sustainability in a Telecoupled World. Ecology and Society, Published online: Jun 17, 2013 | doi:10.5751/ES-05873-180226, v. 18, n. 2, 17 jun. 2013.

LIU, J. et al. Systems integration for global sustainability. ScienceAmerican Association for the Advancement of Science, , 27 fev. 2015.

LIU, J. et al. Spillover systems in a telecoupled Anthropocene: typology, methods, and governance for global sustainability. Current Opinion in Environmental Sustainability, v. 33, p. 58–69, 1 ago. 2018.

MARTÍNEZ-ZARZOSO, I.; OUESLATI, W. Do deep and comprehensive regional trade agreements help in reducing air pollution? International Environmental Agreements: Politics, Law and Economics, v. 18, n. 6, p. 743–777, 1 dez. 2018.

MARTINS, M. M. V. et al. NORMAS VOLUNTÁRIAS DE SUSTENTABILIDADE E SUA IMPORTÂNCIA NO COMÉRCIO INTERNACIONAL. Boletim de Economia e Política Internacional - BEPI, n. 34, p. 1–26, dez. 2022.

MARTINS, M. M. V. et al. Climate finance towards greener agriculture: a win-win strategy. revista tempo do mundo, v. 4, abr. 2024.

MINGORRÍA, S. et al. The oil palm boom: Socio-economic implications for Q'eqchi' households in the Polochic valley, Guatemala. Environment, Development and Sustainability, v. 16, n. 4, p. 841–871, 1 abr. 2014.

MOON, S.; LEE, H. The Role of Standards-Related Capacity Building on the Sustainable Development of Developing Countries: Focusing on the Korea's Standards-Related AfT Case in Bolivia. Sustainability 2020, Vol. 12, Page 5199, v. 12, n. 12, p. 5199, 25 jun. 2020.

MORALES, L. F. B. et al. Apertura comercial y medio ambiente. Interciencia, v. 27, n. 5, p. 259–263, 2002.

MOSER, C.; LEIPOLD, S. Toward "hardened" accountability? Analyzing the European Union's hybrid transnational governance in timber and biofuel supply chains. Regulation & Governance, v. 15, n. 1, p. 115–132, 1 jan. 2021.

MOUZAM, S. M. UNESCAP and UNCTAD, Asia-Pacific Trade and Investment Report 2019: Navigating Non-tariff Measures (NTMs) Towards Sustainable Development , United Nations Economic and Social Commission for Asia and the Pacific and United Nations Conference on Trade and Development . Journal of Asian Economic Integration, v. 2, n. 1, p. 119–122, abr. 2020.

MUNHOZ, L.; VARGAS, D.; VALENTE, F. Medidas ambientais e comércio internacional evolução dos princípios ambientais nas disputas comerciais. Observatório de Bioeconomia, p. 1–32, 2023.

NEWIG, J. et al. What is governance in global telecoupling? Ecology and Society, Published online: Sep 04, 2019 | doi:10.5751/ES-11178-240326, v. 24, n. 3, 4 set. 2019.

NEWIG, J. et al. Governing global telecoupling toward environmental sustainability. Ecology and Society, Published online: Nov 19, 2020 | doi:10.5751/ES-11844-250421, v. 25, n. 4, p. 1–17, 19 nov. 2020.

NIJMAN, V. CITES-listings, EU eel trade bans and the increase of export of tropical eels out of Indonesia. Marine Policy, v. 58, p. 36–41, 1 ago. 2015.

NONNENBERG, J. M. et al. EFEITOS DA LEI EUROPEIA CONTRA DESMATAMENTO SOBRE AS EXPORTAÇÕES BRASILEIRAS. Ipea, v. 3016, n. Texto para Discussão, 2024a.

NONNENBERG, J. M. B. et al. Climate Change and agrifood production: a problem to be tackled by devoloped and developing countries. revista tempo do mundo, v. 34, p. 263–296, abr. 2024b.

PORTER, M. E.; VAN DER LINDE, C. Toward a New Conception of the Environment Competitiveness Relationship. Journal of Economic Perspectives, v. 9, p. 97–118, 1995.

PRAG, A.; LYON, T.; RUSSILLO, A. Multiplication of Environmental Labelling and Information Schemes (ELIS): Implications for Environment and Trade: OECD Environment Working Papers. [s.l: s.n.]. Disponível em: <https://www.oecd-ilibrary.org/environment/multiplication-of-environmental-labelling-and-information-schemes-elis_5jm0p33z27wf-en>.

QUEIROZ, F. A. DE. Meio ambiente e comércio internacional: Relação sustentável ou opostos inconciliáveis? Argumentos ambientalistas e pró-comércio do debate. Contexto Internacional, v. 31, n. 2, p. 251–283, ago. 2009.

RICARDO, D. The Theory of Comparative Advantage. In: SRAFFA, P.; DOBB, M. H. (Eds.). Principles of Political Economy and Taxation. London: Cambridge University Press, 1817. v. 1.

SAMUELSON, P. A. International Trade and the Equalisation of Factor Prices. The Economic Journal, v. 58, n. 230, p. 163–184, 1 jun. 1948.

SANDARUWAN, K. P. G. L.; WEERASOORIYA, S. A. Non-tariff measures and sustainable development: The case of the European Union import ban on seafood from Sri Lanka. Bangkok: [s.n.]. Disponível em: <www.econstor.eu>.

SANTERAMO, F. G.; LAMONACA, E. On the trade effects of bilateral SPS measures in developed and developing countries. The World Economy, v. 45, n. 10, p. 3109–3145, 1 out. 2022.

SCHRÖTER, M. et al. Interregional flows of ecosystem services: Concepts, typology and four cases. Ecosystem Services, v. 31, p. 231–241, 1 jun. 2018.

SIELFELD OCAMPO, S. The USMCA and its Environmental Protection Provisions. En las Fronteras del Derecho, v. 1, 20 abr. 2022.

SILVA, F. D. S. et al. Virtual pollination trade uncovers global dependence on biodiversity of developing countries. Science Advances, v. 7, n. 11, p. 6636–6646, 1 mar. 2021.

UNCTAD. The Unseen Impact of Non-Tariff Measures: Insights from a new database. Geneva: [s.n.]. Disponível em: <https://unctad.org/system/files/official-document/ditctab2018d2_en.pdf>. Acesso em: 4 jun. 2023.

UNCTAD. International Classification of Non-tariff Measures - 2019 edition. New York: [s.n.]. Disponível em: <https://unctad.org/system/files/official-document/ditctab2019d5_en.pdf>. Acesso em: 4 jun. 2023.

UNCTAD. TRAINS Online. Disponível em: <https://trainsonline.unctad.org/detailedSearch>. Acesso em: 4 jun. 2023.

UNITED NATIONS. About Montreal Protocol. Disponível em: <https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol>. Acesso em: 7 dez. 2024.

USTR. United States-Mexico-Canada Agreement (USMCA). Disponível em: <https://ustr.gov/sites/default/files/files/Press/fs/USMCA/USMCA_Environment.pdf>. Acesso em: 7 dez. 2024.

VINCENT, A. C. J. et al. The role of CITES in the conservation of marine fishes subject to international trade. FISH AND FISHERIES, v. 15, n. 4, p. 563–592, dez. 2014.

WIEDMANN, T.; LENZEN, M. Environmental and social footprints of international trade. Nature GeoscienceNature Publishing Group, , 1 maio 2018.

WIEDMANN, T. O. et al. The material footprint of nations. Proceedings of the National Academy of Sciences of the United States of America, v. 112, n. 20, p. 6271–6276, 19 maio 2015.

WONGRAK, G. et al. The Impact of the EU IUU Regulation on the Sustainability of the Thai Fishing Industry. SUSTAINABILITY, v. 13, n. 12, jun. 2021.

WTO. ARTICLE XX GENERAL EXCEPTIONS. [s.l: s.n.]. Disponível em: <https://www.wto.org/english/res_e/booksp_e/gatt_ai_e/art20_e.pdf>. Acesso em: 8 jul. 2023.

YOUNG, M. A. International trade law compatibility of market-related measures to combat illegal, unreported and unregulated (IUU) fishing. MARINE POLICY, v. 69, p. 209–219, jul. 2016.

YU, H.; WANG, R.; ZHANG, A. Unraveling the impact of environmental provisions in preferential trade agreements on green total factor energy efficiency. Journal of Environmental Management, v. 362, 1 jun. 2024.

3. NON-TARIFF MEASURES TOWARDS ENVIRONMENTAL GOVERNANCE OF INTERNATIONAL TRADE: THE CASE OF THE FISHERIES SECTOR

1. INTRODUCTION

Fishery products are integral to global food security, providing high-quality proteins, vitamins, minerals, fatty acids, and omega-3 to populations worldwide. In 2022, fisheries and aquaculture production contributed around 20.7 kg of food per capita, providing at least 15% of their average animal protein intake from fisheries, reaching over 50% in several countries in Asia and Africa (FAO, 2024). International trade has expanded access to these aquatic products, making fish and fishery products among the most traded food commodities globally, with around 37% of total production exported in 2022 (FAO, 2022). This trade not only enhances food and nutritional security but also generates export revenue, employment, and added value, especially for small island developing states where fisheries constitute a significant portion of trade and gross domestic product (GDP) (FAO, 2022; SUMAILA; BELLMANN; TIPPING, 2016).

However, when considering international trade as a telecoupled system, its role extends beyond socioeconomic aspects. Their ecological interactions embedded in fisheries trade flows raise concerns about environmental sustainability. Demand-driven international trade intensifies fishing activities, causing overfishing and the exploitation of stocks at levels that exceed natural replenishment rates (ASIEDU et al., 2021; WANG; TSAI, 2023). This overexploitation disrupts marine ecosystems, threatens biodiversity, and undermines the economic stability of fisheries, especially in countries with limited management capacity (CHAISSE; CHAKRABORTY; KUMAR, 2024; SARKODIE; OWUSU, 2023).

In addition, telecoupled international trade leads to habitat degradation due to destructive fishing gear, including bottom trawling (CRAMER; KITTINGER, 2021), and increases pollution linked to transportation and processing (Parker; Tyedmers, 2015). Bycatch and illegal, unreported, and unregulated (IUU) fishing intensify these issues by capturing non-target species and hindering conservation efforts, ultimately affecting the long-term availability of marine resources (FANG; ASCHE, 2021; HE, 2022; MOROVATI et al., 2024).

The interconnected nature of marine ecosystems, migratory species, and telecoupled trade suggests that global environmental governance requires transboundary instruments capable of influencing production dynamics. Without such efforts, these resources risk collapse, reflecting the "tragedy of the commons" (HARDIN, 1968). One potential measure to govern these environmental aspects of telecoupled international trade is the use of Non-Tariff Measures.

NTMs include various policies that influence trade flows and prices without relying on customs tariffs. They are mandatory regulations that can address several objectives, such as protecting human health and conserving the environment (UNCTAD, 2013, 2018). In fisheries conservation, NTMs can set import requirements for fish products, for example, by banning imports of endangered species (FRIEDMAN et al., 2018) or species caught with destructive or non-selective gear (AULIYA et al., 2024; FOSTER et al., 2019). Since these regulations are mandatory, exporters must adjust their practices to maintain market access (SHUKLA, 2024).

Considering international trade as a telecoupled system that requires governance to address emerging environmental problems, the adoption of NTMs by importers can respond directly to these issues. NTMs can be introduced more quickly than other transnational mechanisms (ESTY, 2001), adapt to changing conditions (VINCENT et al., 2014b), and integrate with other, more participatory governance mechanisms (He, 2019)

This leads to the question: can NTMs serve as instrument of environmental governance for telecoupled fisheries trade? This raises the hypothesis that NTMs may enforce conditions that make trade flows more environmentally sustainable. To test this, one approach is to verify if, under NTMs related to sustainable fishing, countries with lower environmental performance experience reduced trade flows compared to countries with higher environmental performance.

This test is appropriate because countries with lower environmental performance may incur higher costs to comply with NTM requirements and may decide not to export to regulated markets. Such decisions often arise from regulatory distance between the importer's environmental demands and the exporter’s domestic practices (BOOTH et al., 2021). Thus, adopting NTMs could make trade flows more aligned with environmental objectives.

Furthermore, to consider NTMs as effective governance instruments, they must promote sustainable practices while avoiding trade diversion to countries without environmental restrictions. For this, it expected countries transitioning to more sustainable practices should show more positive outcomes compared to those already at the highest levels of environmental performance. This ensures NTMs drive meaningful change rather than reinforcing existing dynamics. While better-prepared countries are expected to benefit, NTMs should also support countries striving to improve their environmental standards. Greater gains for transitioning countries do not diminish benefits for high-performing ones but reflect the desired outcome of broader market participation through improved sustainability.

To test these hypotheses, the first step involved identifying NTMs related to sustainable fishing using the UNCTAD database (2024). Although the UNCTAD database is comprehensive, it does not classify NTMs by environmental objectives. Kravtchenko et al. (2019), in collaboration with UNCTAD, created a global concordance matrix linking NTMs to Sustainable Development Goals (SDG). For this study, the global matrix was adapted to more thoroughly map NTMs related to sustainable fishing.

The analysis then estimated the effects of these sustainable fishing NTMs on trade flows for countries at different environmental performance levels. Exporting countries were divided into tertiles based on indicators related to bycatch reduction and endangered fisheries species. These indicators were chosen due to the possibility of association with the objectives of the NTMs, given the limitation of available indicators.

The methodology used was the gravity model, a common tool in international trade research due to its ability to explain trade flows through variables such as NTMs (HEAD; MAYER, 2014). The study considered bilateral fisheries trade flows among countries accounting for 95% of total imports and exports from 2012 to 2022.

This study provides quantitative insights that connect NTMs with telecoupled international trade, contributing to the literature on environmental governance arrangements. It also emphasizes how trade measures can encourage sustainability, thereby reframing the relationship between trade and the environment. Additionally, it introduces a methodological contribution by integrating NTMs, international trade, and environmental performance into the gravity model. It adapts the global concordance matrix developed by Kravtchenko et al. (2019) and UNCTAD, enabling a more comprehensive identification of NTMs related to sustainable fisheries.

This study is divided into four sections, in addition to this introduction. The first section examines the main environmental issues associated with international fisheries trade, identifying areas where environmental governance should focus. It then seeks to identify and assess the commercial implications of NTMs aimed at addressing these issues. The following section outlines the methodology, detailing both the mapping of NTMs related to environmentally sustainable fishing and the gravity model specifications. The following section interprets the regression results and, finally, conclusions.

2. ADDRESSING ENVIRONMENTAL CHALLENGES IN TELECOUPLED FISHERIES TRADE: ENVIRONMENTAL RELATED NTMS AND THEIR TRADE IMPLICATIONS

The socio-ecological interactions of telecoupled international fisheries trade are marked by their complexity and interconnection. Mapping the key drivers of degradation in fishery resources and their ecosystems associated with this trade is essential for guiding environmental governance arrangements. Activities related to telecoupled international trade contribute to, among other issues, marine pollution, overexploitation of biological resources, overfishing, and habitat deterioration, all of which threaten critical ecosystem services (WANG; TSAI, 2023).

The growing international demand for fisheries resources intensifies fishing efforts, often resulting in overfishing where stocks are exploited faster than they can replenish. Notably, the percentage of fish stocks fished at biologically unsustainable levels increased from 10% in 1974 to 35.4% in 2019 (FAO, 2022).

Studies indicate that overexploitation has caused declines and even collapses in seafood populations, such as species Napoleon Wrasse (*Cheilinus undulatus)* and Queen Conch (*Strombus gigas)* (ACOSTA, 2006; DE MITCHESON; LIU; SUHARTI, 2010). Moreover, overfishing of top predators like sharks, can lead to ecological disruptions. The removal of these predators causes cascading effects throughout the ecosystem, altering the abundance of species at lower trophic levels and leading to instability (PORCHER; DARVELL, 2022; SOVACOOL, 2009). This imbalance can result in the proliferation of opportunistic species, further degrading marine ecosystems (HOLCOMBE et al., 2022). Thus, overfishing not only reduces fish populations, but also disrupts marine ecosystems, impacting species dependent on these fish for sustenance (PORCHER; DARVELL, 2022).

The need to meet the growing global demand for fishery resources also is related to destructive fishing methods that contribute significantly to habitat destruction. Techniques like bottom trawling damage essential marine habitats such as coral reefs and seagrass beds, relevant for the health of marine ecosystems and the reproduction of numerous fish species (CRAMER; KITTINGER, 2021; KURNIA, 2024). Another practice like cyanide fishing degrades habitats, negatively affecting a wide range of species beyond the targeted ones (BIONDO; BURKI, 2020; COHEN; VALENTI; CALADO, 2013). Thus, the use of harmful fishing gear destroys benthic habitats, reducing biodiversity and change habitat structures (ERIK; DAGTEKIN, 2022; HAQUE; CAVANAGH; SPAET, 2022).

Harmful fishing gear as a response to demand for specific products also heightens threats to biodiversity through accidental capture and subsequent discards of non-target species, including threatened and protected species (PINCINATO et al., 2022). Bycatch of organisms such as sea turtles, seabirds, and marine mammals contributes to the mortality of endangered species, disrupting biodiversity and ecosystem balance (ERIK; DAGTEKIN, 2022; JONES et al., 2018). For instance, fishing for Brownback Croaker (*Nibea squamosa)* in Papua New Guinea for swim bladders has resulted in increased bycatch of endangered sharks and rays (AMEPOU et al., 2024).

All these environmental problems are aggravated by Illegal, unreported, and unregulated (IUU) fishing. IUU fishing is highly linked to global fisheries resources supply chains. It intensifies overfishing and undermines conservation efforts due to insufficient regulation and enforcement in international fish (FANG; ASCHE, 2021; HE, 2022; OSTERBLOM; BODIN, 2012; TIAN, 2024). A study on the small pelagic fishery in Ghana highlights that the total landing of round sardines peaked in 2000 and has since shown a drastic decline of 71% driven by IUU fishing, the increase in the capacity of fishing fleets and the resulting overfishing (ASIEDU et al., 2021).

Combating IUU fishing is complex. Different maritime jurisdictions, such as the Exclusive Economic Zone (EEZ) and the high seas, often have regulatory gaps and overlaps. In addition, disparities in enforcement capacity and penalties applied to offenders create an environment conducive to IUU fishing (HE, 2022; SONG et al., 2020; TIAN, 2024). Countries with less robust monitoring and control systems, or with lenient sanctions, become prime targets for illegal operators. Specific strategies are used to evade regulations, such as transshipment on the high seas far from the jurisdiction of any coastal country, allowing illegal operators to "launder" their catches by mixing them with fish from legal sources (DODDEMA et al., 2020); and the practice of registering fishing vessels in countries with less stringent regulations, known as "flags of convenience", allows illegal operators to escape enforcement and sanctions (HE, 2022; LE GALLIC, 2008).

This issue is particularly acute in developing countries, which are often dependent on fisheries exports, which end up increasing pressure on local fisheries resources (SARKODIE; OWUSU, 2023; YE; GUTIERREZ, 2017). Furthermore, many developing countries have weak fisheries management systems (CHAISSE; CHAKRABORTY; KUMAR, 2024; IBARRA; REID; THORPE, 2000), where increased fishing efforts require more vessels to meet global market demands (AYLESWORTH; PHOONSAWAT; VINCENT, 2018; JIMENEZ et al., 2020).

An important development of this problem is pollution associated with increased transportation and processing of fish for international trade exacerbates habitat destruction. This includes greenhouse gas emissions, effluent discharges from processing facilities, and plastic pollution from fishing gear (PARKER; TYEDMERS, 2015). These practices feedback climate change adds to these challenges by changing the temperature of the oceans affecting the distribution, abundance and survival of fish stocks, including small-scale fisheries (VIANNA et al., 2020).

Although the environmental challenges associated with international fisheries trade are widely recognized, NTMs as governance instruments for telecoupled international trade remain underexplored. This is evident in the limited number of studies addressing the commercial implications of NTMs designed to make trade more environmentally sustainable. Most existing research focuses on NTMs related to IUU fishing and CITES regulations, often analyzing specific measures or a limited set of countries.

Kim and Lim (2024) analyzed the EU's yellow and red card system, which targets IUU fishing. Using a structural gravity model, they found that exports from countries receiving yellow and red cards declined by an average of 23% and 83%, respectively. This demonstrates that NTMs aimed at combating IUU fishing can effectively reduce trade flows from countries associated with unsustainable fishing practices.

Fang and Asche (2021) examined the Seafood Import Monitoring Program (SIMP) implemented by the United States, which establishes traceability requirements to combat IUU fishing. Although their study does not explicitly assess the program’s trade impacts, it highlights the U.S.'s significant buyer power for products covered by SIMP. This leverage enables the program to incentivize exporting countries to improve fisheries management practices to retain access to the U.S. market.

CITES regulations also intersect with NTMs, as seen in the work of Kuo and Vincent (2018). Their analysis of the inclusion of seahorses in Appendix II of CITES found a reduction in reported trade volumes, indicating that CITES can influence trade flows for threatened species. This suggests improved trade management and, in some cases, the suspension of exports for the species. However, the study also noted the continued risk of unreported illegal trade, emphasizing the need for stronger oversight.

Despite these insights, studies on NTMs for fisheries sustainability often fail to provide a comprehensive view of their broader trade implications. This may result from a lack of consideration of international trade as a telecoupled system, where sending, receiving, and spillover systems are deeply interconnected. Research often focuses on a single prominent NTM, such as the EU's card system or the U.S. SIMP, typically considering one issuing country without analyzing the evolving scope of NTMs.

To address this gap, the present study investigates the commercial implications of a previously unexplored range of NTMs aimed at environmentally sustainable fisheries, assessing their role as governance instruments for telecoupled international trade. This includes examining NTMs in conjunction with environmental performance indicators linked to key fisheries sustainability challenges, such as reducing bycatch and wasteful practices, restricting harmful fishing gear, and protecting endangered species.

3. METHODOLOGY

3.1. Mapping NTMs Related to Environmentally Sustainable Fisheries: A New Concordance Matrix

Non-Tariff Measures are commonly defined as policy measures, other than ordinary customs tariffs, that can influence international trade by altering prices or quantities (UNCTAD, 2018). Despite this succinct definition, NTMs are highly diverse and complex. Some measures target prices and traded volumes, including administered pricing, antidumping, and countervailing actions. Others regulate quantities through instruments such as non-automatic licensing, quotas, or import bans. Another category focuses on product characteristics by introducing sanitary requirements, technical standards, or labeling rules. There are also NTMs that do not directly address goods themselves but influence processes like customs procedures or administrative practices (MOUZAM, 2020).

Two widely used official sources for NTM data are UNCTAD's TRAINS database and the World Trade Organization databases. Among the WTO sources, ePing compiles NTMs notified under the SPS and TBT agreements, while the Environmental Database (EDB) collects environment-related notifications and measures identified in Trade Policy Reviews. However, ePing and EDB may not capture the full range of implemented measures, as only NTMs deviating from international standards require notification and practices vary among countries. Many states provide partial notifications or fail to report final regulation adoptions, leaving significant data gaps. These constraints make TRAINS a more comprehensive option, as it includes both notified measures and those found in national legislation and other sources, offering a broader and more detailed perspective on NTMs worldwide.

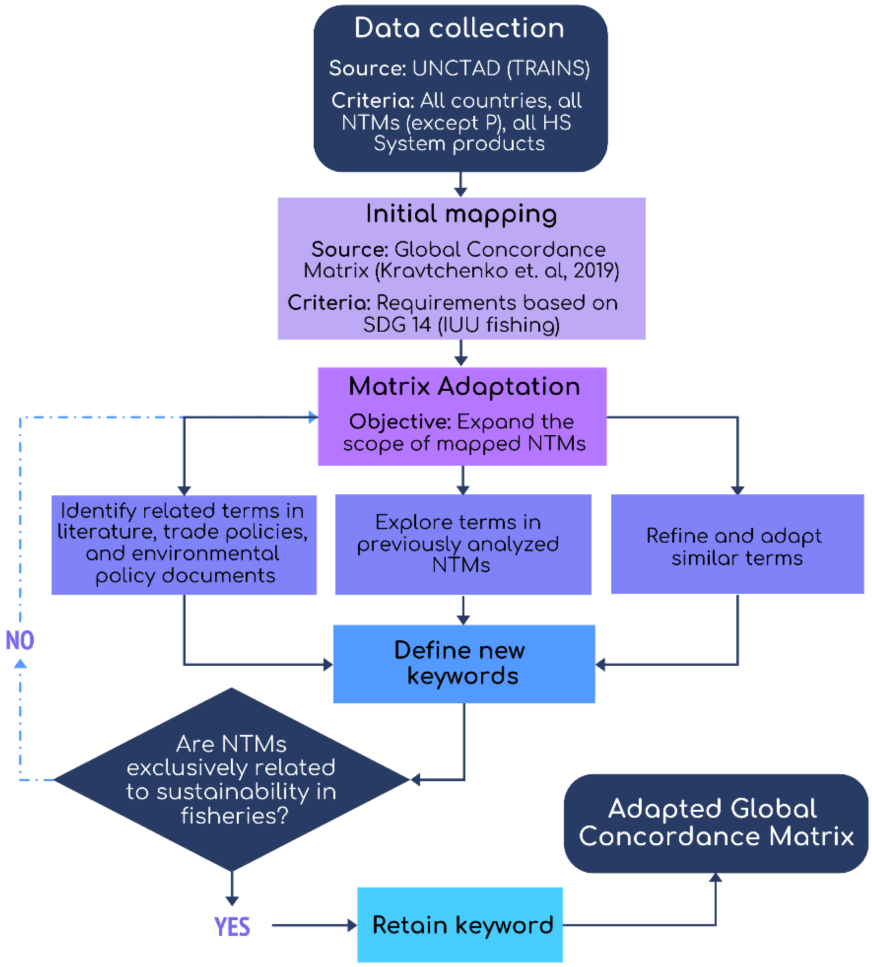
Although UNCTAD classifies NTMs into 178 distinct measures (see Annex), there is no classification system based on policy objectives such as natural resource conservation or wildlife protection. Nor is there a specific category for exclusively environmental goals. This lack of objective-based categorization complicates environmental analyses, as measures with environmental implications are not easily identifiable. To address this issue, Kravchenko et al. (2019) and UNCTAD developed a global concordance matrix linking NTMs to the Sustainable Development Goals. This matrix allows researchers to identify some NTMs aligned with policy objectives associated with particular SDG.

The global concordance matrix is constructed by: (i) identifying relevant product groups for each SDG; (ii) verifying which NTMs affecting these product groups incorporate policy objectives related to the SDG; (iii) applying keyword searches to refine the matching process (Kravchenko et al., 2019). This approach enables a systematic review of each NTM in the UNCTAD TRAINS database (2024), checking for both relevant products and keywords that indicate alignment with a given SDG.

While the global concordance matrix for SDG 14 ("Life Below Water") was a useful starting point – it mainly assisted in identifying NTMs related to combating Illegal, Unreported, and Unregulated (IUU) fishing – the matrix did not fully capture the diversity of policies that can guide fisheries trade toward greater environmental sustainability.

To overcome this limitation, we developed our own concordance matrix, adapted from Kravchenko et al. (2019), to map NTMs specifically targeting environmentally sustainable fisheries. The adaptation process is depicted in Figure 2.

Figure 2 - Constructing the Concordance Matrix for Mapping NTMs Related to Environmentally Sustainable Fisheries



Source: Author's elaboration

Applying the same product and keyword matching methodology, we expanded the keyword set based on literature on international fisheries trade governance, as well as countries' trade and environmental policy documents. We included terms related to multilateral environmental agreements such as CITES and the Convention on the Conservation of Species (CCS), as well as keywords on aquatic species conservation, wildlife protection, IUU fishing, bycatch, and harmful fishing gear. We also considered names of national fisheries conservation laws and examined the contents of previously identified NTMs to uncover additional terms. Synonyms, acronyms, and alternate spellings were incorporated, and each matched NTM underwent a regulatory content check to ensure its relevance to fisheries sustainability objectives. This iterative process continued until all identified NTMs aligned with the intended environmental sustainability goals.

The final matrix included 82 keywords, all fisheries products according six-digits Harmonized Systems, and all NTMs types, resulting in the identification of 588 NTMs applied by 74 importing countries and European Union (27). Similar to the approach in Kravchenko et al. (2019), our concordance matrix provides comprehensive information, including the importing countries implementing these NTMs, the products covered, the affected exporting countries, and the relevant implementation and expiration dates, as well as regulatory descriptions. However, it encompasses a broader and focused scope of NTMs related to fisheries sustainability.

These data form the basis for our explanatory variables in the gravity model. To ensure clarity in the analysis, we grouped a sample of the identified NTMs through keywords into three categories: (i) “cites” for the protection of endangered species regulated under CITES; and ii) “prot_gear” protection of fishery resources and requirements that inhibit non-selective fishing. Grouping the NTMs in this manner ensures adequate observation counts for each category and facilitates direct links to relevant environmental indicators. Table 1 presents the three mentioned categories, the keywords used to create them, and the number of NTMs identified based on each category.

Table 1 - Keywords used in mapping NTMs across custom categories and number of NTMs identified

Category	Short description	Keywords	Quantity
cites	CITES-based requirements	"washington convention", "CITES", "convention on international trade in endangered species of wild fauna and flora", "cites.org"	209
prot_gear	Protection of fishery resources and selective fishing	"wildlife protection", "protection and conservation", "protected species", "protection of aquatic wild animals", "protection of wild life", "protected wildlife", "protection of fauna and flora", "fish stocks", "fish stock protection act", "fishery resources protection law", "purse seine", "incidental kill", "incidental serious injury"	88

Note: A single NTM may belong to more than one category.
Source: Author’s elaboration.

3.2. Gravity Model

The analysis uses the gravity model, a well-established approach for examining trade flows (CHENG; WALL, 2005; HEAD; MAYER, 2014). This model is based on the idea that the volume of trade between two countries increases with their economic size and decreases with the costs of connecting them. Larger economies export and import more due to their production capacity and income levels, while greater distances raise transport costs and reduce trade volumes.

Over time, the gravity model has been refined to incorporate supply and demand functions from both the exporting and importing sides. Anderson and Van Wincoop (2003) provided a derivation that became widely accepted, based on the supply and demand functions of exporting and importing countries, defined by the non-linear equation with the multiplicative error term, expressed according to the following structural form:

$$X_{ijt}^{p} = \frac{E_{jt}^{p} Y_{it}^{p}}{Y_{t}^{p}} \left(\frac{\tau_{ijt}^{p}}{P_{jt}^{p} \Pi_{it}^{p}} \right)^{1-\sigma_p} e_{ij}^{p} \tag{1}$$

$$(\Pi_{it}^{p})^{1-\sigma_p} = \sum_{j} \left(\frac{\tau_{ijt}^{p}}{P_{jt}^{p}} \right)^{1-\sigma_p} \frac{E_{jt}^{p}}{Y_{t}^{p}} \tag{2}$$

$$(P_{jt}^{p})^{1-\sigma_p} = \sum_{1} \left(\frac{\tau_{ijt}^{p}}{P_{jt}^{p}} \right)^{1-\sigma_p} \frac{Y_{it}^{p}}{Y_{t}^{p}} \tag{3}$$

The model allows explaining bilateral exports: $X_{ij}^{p}$are exports of product p from country i to country j in year t; Y_{it}^{p},, Y_{t}^{p} are the production of p in country i and the aggregate world production of p in year t, respectively; E_{jt}^{p} represents j s expenditure to obtain p in year t, τ_{ijt}^{p} refers to i 's commercial costs to send p to country j in year t, τ_{ijt}^{p} represents the elasticity of substitution between product groups, e_{ij}^{p} _ is the random error term and, P_{jt}^{p}) represents the internal multilateral resistance and captures the dependence of imports from country j on the trade costs of all possible suppliers of p. Π_{it}^{p} indicates external multilateral resistance and controls the fact that exports from country i to country j depend on trade costs across all possible exporters. Theoretically, the consideration of multilateral resistance terms was fundamental for the microfoundation of the gravitational model.

When building the model, Anderson and van Wincoop (2004) demonstrate that commercial costs τ_{ijt}^{p}) can be represented as a function of observable variables z_{ijt}^{m}, as indicated in Equation (4). The literature tends to associate it with a set of geographic or historicalinstitutional variables – such as distance, language, contiguity, and common cultural ties – to policy measures that affect bilateral flows, such as tariffs and subsidies.

$$\tau_{ijt}^{p} = \sum_{m=1}^{M} \quad (z_{ijt}^{m})^{\gamma m} \tag{4}$$

Given the multiplicative form of Equation (4) and, assuming that it remains the same for each period t, it becomes possible to linearize it to obtain:

$$lnX_{ijt}^{p} = ln\, ln\, Y_{it}^{p} \; + lnE_{jt}^{p} - ln\, ln\, Y_{t}^{p} + (1-\sigma_p)\gamma m \sum_{m=1}^{M} \quad lnz_{ijt}^{m}(1-\sigma_p)\left[ln\, ln\, \Pi_{it}^{p} - ln\, ln\, P_{jt}^{p} \;\right] + lne_{ij}^{p} \tag{5}$$

Given the multiplicative form of Equation (4) and its linearization (5) for each period t, the main challenge lies in properly accounting for time-varying, unobservable characteristics that influence trade. Estimating a gravity model without controlling for such variations risks producing biased results, as evolving country conditions – ranging from shifts in economic policies to broader structural changes – can affect trade flows in ways not fully captured by observable variables (CHENG; WALL, 2005). To address this issue, the specification includes directional fixed effects that vary over time for both exporters and importers at the product level (exporter-product-time and importer-product-time). These fixed effects control for the unobservable multilateral resistance terms of Anderson and van Wincoop (2003) or, alternatively, for consumer and producer prices. Beyond absorbing structural multilateral resistances, these exporter-product-time and importer-product-time effects also account for size-related characteristics and any other country-product-specific factors that could influence trade, preventing them from confounding the impacts of policies or shocks (LARCH; LUCKSTEAD; YOTOV, 2024).

In addition, the model incorporates country-pair-product fixed effects, which absorb all time-invariant bilateral determinants of trade. This eliminates the need to include traditional gravity variables (e.g., distance, shared borders, common language, colonial ties) as separate regressors, a practice supported by findings that these standard proxies may not accurately represent bilateral trade costs (AGNOSTEVA; ANDERSON; YOTOV, 2019; EGGER; NIGAI, 2015). The use of country-pair-product fixed effects also addresses the endogeneity between trade flows and bilateral policy measures, by filtering out any unobserved or unmodeled correlation between policy variables and the error term (BAIER; BERGSTRAND, 2007; YOTOV et al., 2016). When time-varying bilateral determinants of trade matter – for instance, in the case of trade agreements, tariffs, or NTMs – these can be included as additional regressors, making it possible to more clearly identify their influence on trade once the stable bilateral influences have been removed (LARCH; LUCKSTEAD; YOTOV, 2024).

For scenarios involving unilateral or non-discriminatory policies, common with many NTMs, Heid, Larch, and Yotov (HEID; LARCH; YOTOV, 2021) recommend incorporating intra-national (domestic) trade flows. Because these policies do not affect internal trade, domestic flows serve as a natural benchmark that helps isolate the effect of non-discriminatory measures on international exchanges. This approach reduces collinearity and prevents the absorption of non-discriminatory policies by fixed effects. Including domestic data thus clarifies how such measures influence global trade patterns and helps detect trade diversion or import substitution triggered by specific policies or shocks (YOTOV, 2022).

Another layer of complexity emerges from zero trade flows. A representative sample that includes a wide range of country pairs and products is likely to generate numerous zero-valued observations (BACCHETTA; FUGAZZA; GRETHER, 2012). To handle these zeros and to ensure consistency, the Poisson Pseudo Maximum Likelihood (PPML) estimator of Santos Silva and Tenreyro (2006) is employed. PPML accommodates zero trade flows naturally and delivers consistent estimates even in the presence of heteroskedasticity (Yotov et al., 2016). Standard errors are clustered by country-pair-product to account for potential intragroup correlation over time (LARCH; LUCKSTEAD; YOTOV, 2024). Furthermore, the PPML-HDFE (High-Dimensional Fixed Effects) approach is used to manage large numbers of fixed effects efficiently, which is essential when working with highly disaggregated data that involve multiple dimensions (country-pair, product, time).

In summary, this combination of methodological choices – directional time-varying fixed effects at the exporter-product-time and importer-product-time level, country-pair-product fixed effects, inclusion of domestic trade flows, and the PPML-HDFE estimation technique – provides a more comprehensive and transparent framework for understanding how policies, internal adjustments, and various structural factors shape international trade flows.

Specification:

To capture the influence of Non-tariff Measures and their interaction with the environmental performance of exporting countries, the empirical model can be represented as follows:

$$M_{ijkt} = \exp(\beta_1 Fish\_Ag_{ijt} + \beta_2 \ln(1 + Tariff_{ijkt}) + \beta_3 NTM\_Other_{ijkt} + \sum_{m=1}^{2}\sum_{n=1}^{3} \theta_{mn} \left((NTM\text{-}Env\_indicator)_{m,ijkt} \times I(tertile\ n) + \gamma_{ict} + \delta_{jct} + \tau_{ijc}\right) + \varepsilon_{ijkt} \quad (6)$$

The term $\sum_{m=1}^{2}\sum_{n=1}^{3} \theta_{mn} \left((NTM\text{-}Env\_indicator)_{m,ijkt} \times I(tertile\ q)\right)$ captures the interaction between specific NTM imposed by the importing country (Table 1) and the environmental performance tertiles of the exporting country (Table 3). This interaction term consists of two nested summations: the outer summation $(m = 1, 2)$ $l$oops over the four pairs of NTMs and their corresponding environmental and indicators while the inner summation $(n = 1, 2, 3)$ loops over the three terciles of the environmental indicators. Specifically:

1. The outer summation (m) represents the four NTM-environmental indicator pairs:
   1.1. $cites$ represents a vector of NTMs based on the CITES framework, while $cites\_exp$ reflects the exports of fish species listed under Appendices of CITES.
   1.2. $prot\_gear$ represents a vector of NTMs related to the protection of fishery resources and restrictions on harmful fishing gear. The associated environmental indicator, $discarded$, reflects efforts to reduce fish discards;

Thus, we arrive at the set of environmental indicators presented in Table 2.

Table 2 - Environmental Indicators used in the Model

Environmental indicator	Description	Available period	Unit	Source
$cites\_exp$	Trade records as reported by Parties in their annual reports to the e Convention on International Trade in Endangered Species of Wild Fauna and Flora. Larger export volumes are associated with lower environmental performance, while smaller export volumes correspond to higher environmental performance.	2012-2022	Quantity (kg)	CITES
$discarded$	The proportion of a country's total catch in the global ocean that is discarded, instead of landed and used. This indicator serves as a proxy of bycatch and thus of untargeted and wasteful fishing practices. The higher the score, the better the environmental performance in avoiding discards.	2012-2022	Score 0-100	Environmental Performance Index - YALE and Sea Around Us

Source: Author's elaboration

2. The inner summation (n) represents the three tertiles of the exporting country's environmental performance indicators, calculated based on the indicator values for each exporter:
   2.1. $n = 1$: Lowest performance (t1 - first tertile)
   2.2. $n = 2$: Intermediate performance (t2 - second tertile).
   2.3. $n = 3$: Highest performance (t3 - third tertile).

For the $cites\_exp$ environmental indicator, the inverse logic was applied in the creation of the tertiles. Thus, as with the other indicators, higher environmental performance corresponds to a higher tertile, while lower environmental performance corresponds to a lower tertile.

To calculate the performance tertiles, the exporter-year dataset was used. The tertiles were determined by dividing the values of the environmental indicator column into three equal groups based on the data distribution. Given that some variables include missing data and others have values clustered very closely, a global tertile approach was applied, calculating tertiles for the entire column rather than on a year-by-year basis. This method ensures consistency in the data, which is particularly important for maintaining the reliability and comparability of results in the gravity model analysis.

Each interaction term $\theta_{mn}((NTM\text{-}Env\_indicator)_{m,ijkt} \times I(tertile\ n))$ measures the differential impact of the corresponding NTM on trade flows M_{ijkt} for exporters classified within the n-th tertile of the environmental indicator. This setup allows us to analyze how the effect of NTMs varies across exporters with different levels of environmental performance. Including these interaction terms is essential for capturing the heterogeneity of NTM impacts. All variables used in the model, along with their descriptions, are presented in Table 4.

Table 3 - Variables Used in the Model and Their Descriptions

Variable		Unity	Source
M_{ijkt}	The nominal quantity of imports of good k by country i from country j in year t, including the quantity of domestic trade, total gross production, and total exports of product k in year t. The variables i and j represent the importers and exporters, which vary depending on the pair of NTM-environmental indicator, as only countries with data for the environmental indicator are considered. A two-year interval was	Quantity (ton)	UNCONTRADE - WITS and FAO (Fishstat)

	chosen to allow for adjustments in trade flows to trade policies or other trade costs, as recommended by Cheng and Wall (2005). The variable k represents 29 products classified at the 4-digit CPC level, and t covers the period from 2012 to 2022.		
$Fish\_Ag_{ijt}$	Dummy takes value 1, if countries i and j have trade agreement with environmental provisions for fisheries; 0 otherwise.	Binary	Université Laval - IEA Database Project
$Tariff_{ijkt}$	Natural logarithm of one plus the bilateral tariff applied to product k between countries i and j in year t. This transformation ensures that the tariff variable remains defined even when tariffs are zero.	Percent	UNCONTRADE - WITS
NTM_Other_{ijkt}	Dummy take value 1 if there is an NTM from country i to country j in force to product k in year t; 0 otherwise.	Binary	Global Trade Alert
$prot\_gear\_discarded\_tn$	Dummy variables (n=1,2,3) constructed for the interaction between NTMs prot_gear and tertiles of discarded. Equals 1 if the exporter is in the n-th tertile; 0 otherwise.	Binary	UNCTAD TRAINS, YALE
$cites\_cites\_\exp\ \_tn$	Dummy variables (n=1,2,3) constructed for the interaction between NTMs cites and tertiles of cites_exp. Equals 1 if the exporter is in the n-th tertile; 0 otherwise.	Binary	UNCTAD TRAINS, CITES
γ_{ict} δ_{jct} τ_{ijc}	Importer-product_category-time (γ_{ict}) and exporter-time (δ_{jct}) fixed effects (FE), which control specific phenomena in each product category, and country and that vary over time; and τ_{ijc} FE for the country pair and product category, which controls for pair-specific product category phenomena that do not vary over time.	Econometric procedures	
ε_{ijkt}	Error term		

Note: Although the theoretical model is defined in terms of country exports and for j M_{ijkt}, import data are used because they are more reliable traditions. Import flows are monitored more closely by customs agents, as they are subject to import tariffs (BALDWIN; TAGLIONI, 2006).
Source: Author's elaboration

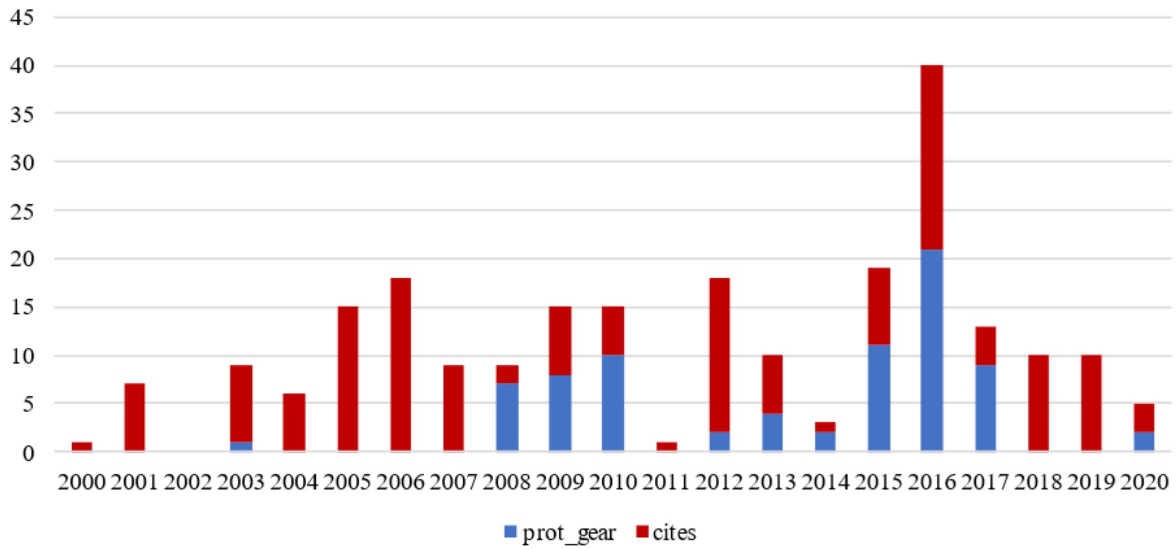
4. RESULTS AND DISCUSSION

Mapping NTMs based on the concordance matrix identified 588 measures related to environmentally sustainable fisheries. This total does not consider disaggregation by affected country or product. A single NTM can apply to all countries on a non-discriminatory (multilateral) basis, and it may cover a wide range of products, from all goods within a specific sector (e.g., fisheries) to all traded products.

For the model, only non-discriminatory measures were considered, as they affect all countries equally and also influence domestic trade. This aligns with WTO rules for implementing NTMs (WTO). Another selection criterion was to include only measures present in most recent data collection years, ensuring that the chosen NTMs were likely in force during the study period. Thus, only measures collected starting from 2015, were considered. This does not mean that the sample includes only NTMs issued from 2015 onward, but rather that it considers NTMs that remained active as of UNCTAD's 2015 data collection, potentially including measures issued as far back as the 1990s, reducing the initial 588 NTMs to 524. By selecting only the indicators of interest (cites_exp and prot_gear), the NTMs were reduced to 267. This number may be lower, as some measures addressed overlapping objectives within a single NTM.

Figure 3 shows the distribution of NTMs used in the model over time, with no clear trend in issuance. The highest number of adoptions occurred in 2016, shortly after the launch of the 2030 Agenda in 2015 and the establishment of SDG 14 (Life Below Water), as well as the inclusion of additional marine species in the CITES lists in 2016.

Figure 3 - Adoption of new NTMs related to environmentally sustainable fisheries over the years



Source: Author’s elaboration.

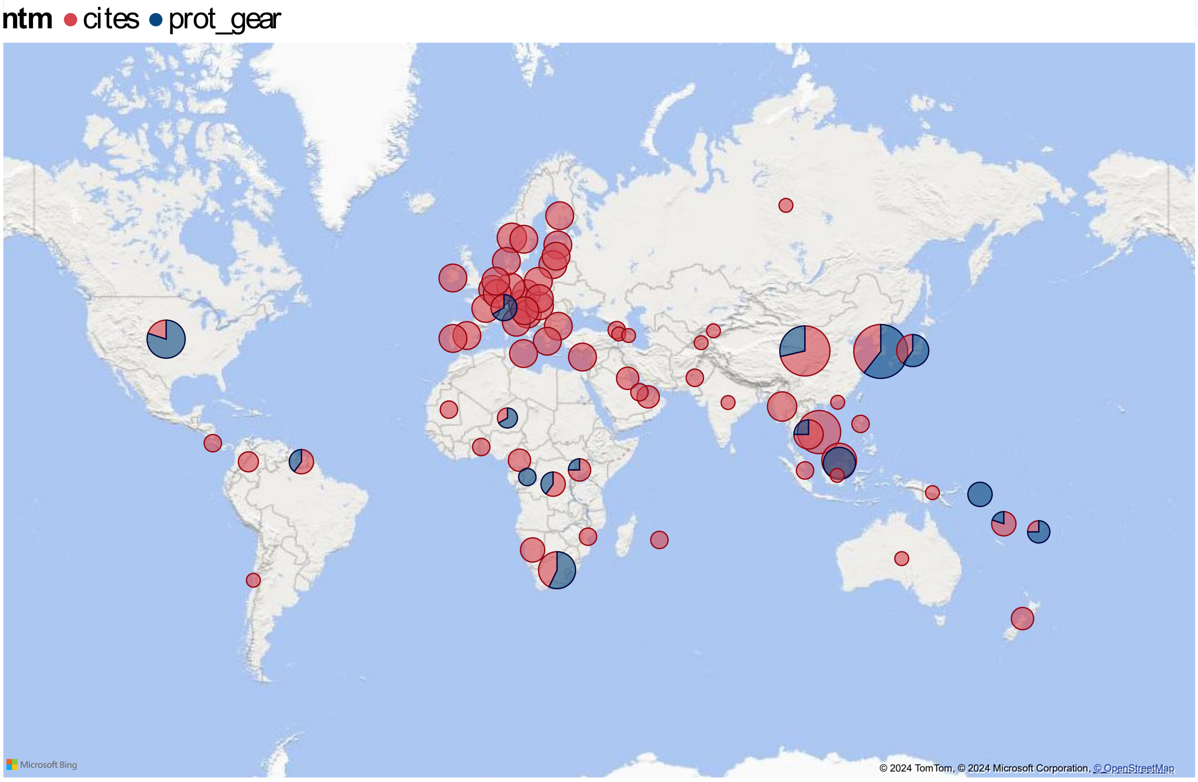
Some important points should be noted regarding Figure 3. Most of these measures remain in effect, generally lacking expiration dates. New measures often introduce additional requirements while existing ones continue. Therefore, the apparent reduction in new NTMs after 2017 does not necessarily indicate diminishing interest in ensuring sustainable fish imports. Instead, it may reflect that the existing measures already provide the desired level of regulation.

From a governance perspective, limiting the introduction of new requirements may be preferable since greater heterogeneity can raise compliance costs (BISPO et al., 2024). Well-designed NTMs can give countries the time needed to adjust their practices.

High-income countries adopted the majority of these NTMs, issuing 131 (about 49% of the total). This share counts the European Union as a single high-income entity, following the TRAINS database practice of grouping NTMs implemented at the bloc level. The EU issued 21 NTMs during the period, mainly related to IUU fishing and CITES. For exporters, compliance with EU measures means access to 27 markets under a single regulatory framework, which can simplify requirements (MARTINS et al., 2022).

The high-income countries that adopted the most fisheries-related environmental NTMs were the Republic of Korea with 33, China with 28, and the United States with 15.

Figure 4 - NTMs related to environmentally sustainable fisheries by country



Source: Author’s elaboration.

Lower-middle-income countries issued 62 measures, led by Vietnam with 20 and Cambodja 8. Upper-middle-income countries implemented 50 measures, mainly from South Africa and Malaysia, which together introduced 24. Low-income countries issued 17 measures, with Democratic Republic of the Congo adopting 5 and Uganda 4.

$cites\_exp$ measures were the most common, totaling 179. This may reflect the dynamic nature of species listings in the CITES Appendices. $prot\_gear$ measures at 88.

After reviewing the dynamics of the data, the next step is to proceed with the analysis to test the hypothesis that NTMs can influence trade flows by assessing whether their requirements are sufficient to encourage more environmentally sustainable trade. Four regressions are estimated, each corresponding to one of the NTM vectors: $prot\_gear$, and $cites$.

For each regression, three new variables were created to represent the presence of each NTM vector for groups of countries divided into tertiles of environmental indicators performance. This approach makes it possible to compare the effect of NTMs across performance tertiles. The expectation is that countries with lower environmental performance will face more constrained export flows compared to those with higher performance. Since the sample composition varies with the availability of environmental performance data, the countries included differ across regressions.

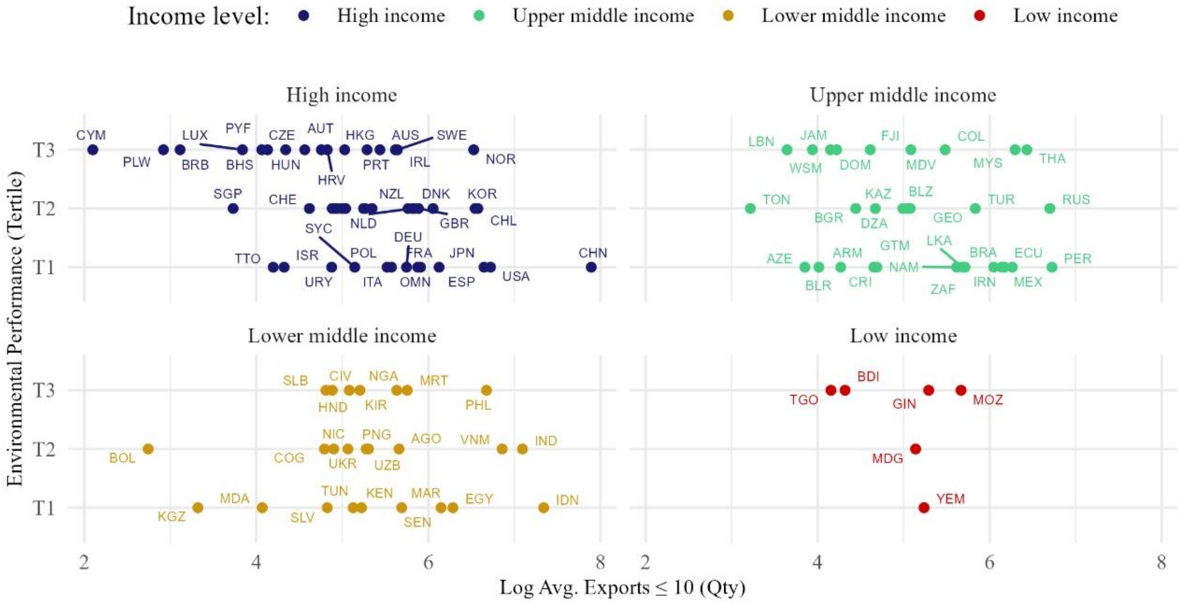
4.1. CITES-based NTMs

This regression focused on NTMs implemented under CITES regulations ($cites$). Variables were created for each tertile, calculated based on the export volume of fisheries species listed in the CITES Appendices when a CITES-based NTM was active for exporting countries $cites\_cites\_exp\_t1$, $cites\_cites\_exp\_t2$ and $cites\_cites\_exp\_t3$. In this classification, countries that export more listed species fall into the lowest performance tertile (t1), while those exporting fewer are placed in higher performance tertiles (t2 and t3). This implies that the higher a country's exports of threatened species, the lower its environmental performance, and conversely, countries exporting fewer such species are considered to have better environmental performance.

CITES regulations are structured into three Appendices with varying levels of protection. Appendix I includes species threatened with extinction, allowing trade only under exceptional circumstances and requiring both import and export permits. Appendix II covers species not yet endangered but potentially at risk, permitting trade under an export permit system to ensure sustainability. Appendix III lists species protected by at least one CITES member, requiring export permits or certificates of origin to align trade with national conservation efforts. These measures aim to balance species conservation with regulated trade.

The sample for this regression includes 108 exporting countries with documented exports of CITES-listed fisheries products: 47 high-income, 30 upper-middle-income, 25 lower-middle-income, and 6 low-income countries. Figure 5 illustrates the distribution of countries across tertiles and the volume of exports by income level and Table 6 provides descriptive statistics. Among high-income countries, distribution is relatively balanced across the tertiles, with most in t2 (38%). However, the highest average export volumes are found in t1, where about 84% of total exports by high-income countries are concentrated.

Figure 5 - Distribution of exporting countries across middle tertiles of environmental performance in “cites_exp” and average export performance, by income level.



Source: Author’s elaboration

Table 4 - Descriptive statistics of average performance in "cites_exp" and exports

Indicators	T1	T2	T3
cites_exp_Max	8908931.58	25216.41	1051.01
cites_exp_Min	25586.98	1212.49	0.00
cites_exp_Mean	424210.66	8015.56	163.29
cites_exp_SD	1484599.26	5995.97	305.44
Trade_Max	78366501.36	12406839.03	4750226.21
Trade_Min	2095.69	553.98	125.00
Trade_Mean	3652405.56	1090245.06	474122.03
Trade_SD	13349263.38	2501260.99	1048239.61

Author’s elaboration

Most middle-income countries (both upper and lower) are located in t1, as are the majority of their exports – 52% for upper-middle-income and 49% for lower-middle-income countries. Low-income countries, though few in number, show 4 out of 6 countries in t3, representing 69% of their collective exports.

The regression results presented in Table 5 align with this study's hypothesis. NTMs show a significant impact on all environmental performance tertiles. In t1, where countries export more CITES-listed species, the effect is negative and significant. In t2 and t3, the effect is positive and significant. This indicates that countries heavily engaged in trading listed species face difficulties meeting NTM requirements, possibly due to non-selective capture methods, limited technical capacity to document sustainable catch practices, or heavy dependence on these exports.

Governing these flows may be more challenging and could require integrating other governance mechanisms (CAZE et al., 2022), such as placing certain products in more restrictive CITES Appendices, introducing stricter export barriers at the national level (TRIBUZY-NETO et al., 2020), reducing regulated product prices (KUO; VINCENT, 2018b), or encouraging a larger number of importing countries to adopt similar import regulations to narrow the funnel of trade in threatened species.

However, increasing import restrictions on a particular threatened species must consider potential shifts in fishing pressure toward similar species, risking new cycles of overexploitation (NIJMAN, 2015). Species-specific measures must acknowledge the interconnected nature of fisheries and consider how reducing demand for one species may affect others.

Abrupt reductions in demand due to regulation can also spur illegal trade (SHERMAN et al., 2023), making it necessary to strengthen monitoring and traceability alongside more stringent import requirements. Studies have noted that after listing certain marine species under CITES, documented trade declined while catches remained high, suggesting incentives for illicit trade (KUO et al., 2018). Understanding international trade as a telecoupled system helps visualize interconnected spillovers and propose responses adapted to these shifting flows.

Table 5 - Estimation results for CITES-based NTMs

Variables	Results
$Fish\_Ag$	0.171
	(0.141)
$Tariff$	4.194***
	(1.598)
NTM_Others	1.062
	(0.743)
$cites\_cites\_exp\_t1$	-1.760*
	(0.237)
$cites\_cites\_exp\_t2$	1.234***
	(0.276)
$cites\_cites\_exp\_t3$	0.863***

	(0.903)
Constant	6.806**
	(3.713)
Observations	93,088
Adj. R^2	0.956

Source: Author's elaboration

On the other hand, $cites\_cites\_exp\_t3$ shows that countries with higher environmental performance – in this case, those exporting fewer threatened species – benefit from CITES-based NTMs because they either avoid or do not rely on such trade. The $cites\_cites\_exp\_t2$ variable also meets expectations, indicating that NTMs offer even greater benefits to countries reducing their exports of CITES-listed species. This outcome is important. Countries in transition (t2) that benefit from NTMs can continue to export legally, rather than redirecting trade to markets that ignore threatened species or resorting to illegal channels.

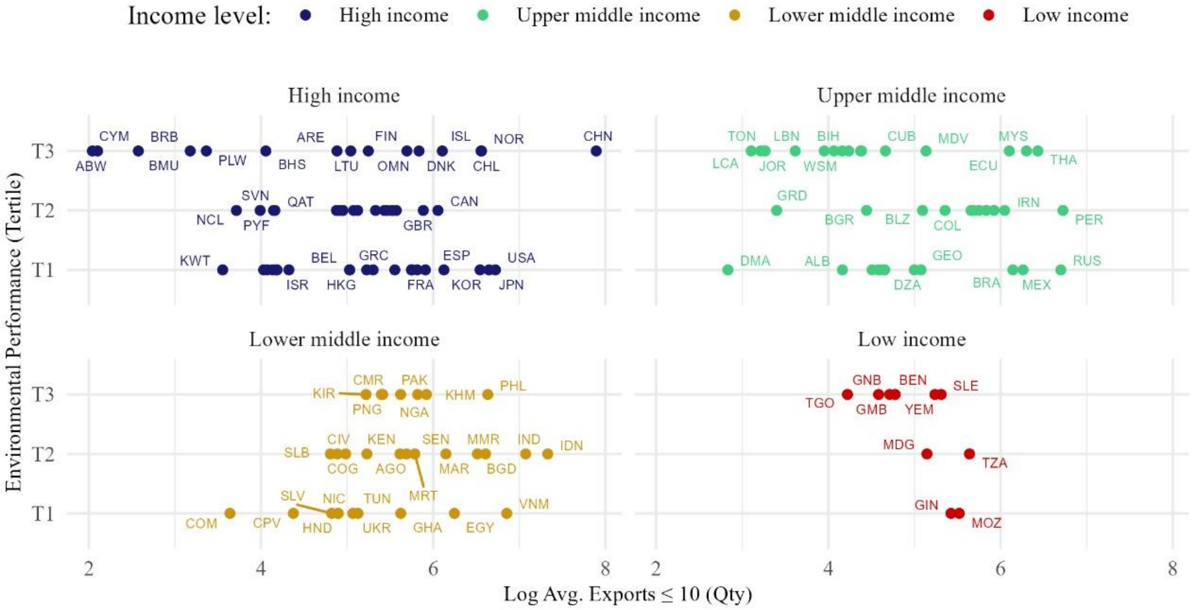
Finally, the tariff variable is positive and significant. This differs from standard gravity model predictions, where tariffs typically reduce trade. Several factors may explain this. The sample focuses on exporters dealing with CITES-listed species, which generally carry higher prices due to conservation requirements (FAO, 2022; KUO; VINCENT, 2018b). Consumers may accept these higher costs, offsetting the usual negative impact of tariffs. Moreover, including a species in CITES listings often reduces the number of exporters, meaning these products are not as affected by ordinary tariffs. These arguments help clarify why tariffs show a stronger positive magnitude than CITES-based regulations in this sample.

4.2 Protection of Fishery Resources and Targeted Practices

To evaluate the effects of NTMs related to the protection of fishery resources and selective fishing practices, variables were created to represent the presence of the $prot\_gear$ NTM vector together with the $discarded$ performance tertiles: $prot\_gear\_discarded\_t1$, $prot\_gear\_discarded\_t2$, and $prot\_gear\_discarded\_t3$, listed in ascending order of environmental performance.

The sample includes a larger number of high-income countries (53), followed by upper-middle (38), lower-middle (29), and low-income countries (10). Contrary to expectations, on average, high-income countries are more frequently found in the lowest-performing tertile (t1), accounting for about 38%, while only about 28% appear in the highest tertile (t3). However, the t3 group accounts for nearly 80% of total exports from high-income countries, while t1 countries represent only 16%. Figure 6 illustrates the distribution of countries by income group and tertile, and Table 6 provides descriptive statistics.

Figure 6 - Distribution of exporting countries across middle tertiles of performance in "discarded" and average export performance, by income level



Source: Author’s elaboration

Table 6 - Descriptive statistics of average performance in “discarded” and exports

Indicators	T1	T2	T3
discarded_Max	45.60909091	69.9363636	100
discarded _Min	0	46.8636364	70.27272727
discarded _Mean	32.53698347	56.3617336	87.53107822
discarded _SD	11.06975097	6.06972265	9.926697142
Trade_Max	7155081.806	21434958.7	78366501.35
Trade_Min	679.448	2507.295	109.0684877
Trade_Mean	847826.9263	1365150.6	2375535.998
Trade_SD	1651672.984	3729672.61	11912708.97

Source: Author’s elaboration

Upper-middle-income and low-income countries are more often found in the highest tertile (t3), with 39% and 60% of countries in this category, respectively, although the latter group’s sample is small. This finding shows that most low-income countries in the sample achieve relatively good performance in selective fishing, avoiding severe bycatch and discard problems despite financial and regulatory constraints (KIM; LIM, 2024). Average exports from low-income countries are relatively similar across tertiles, with 35% in t1, 33% in t2, and 32% in t3.

Lower-middle-income countries tend to be concentrated in the intermediate tertile (t2), about 41% of the countries, and their exports from t2 countries represent roughly 72% of this group's exports. Fewer lower-middle-income countries appear in t3 (about 24%), which is a smaller share than that found for high-income countries.

Table 7 shows the regression results. The variables of interest $prot\_gear\_discarded\_t1$, $prot\_gear\_discarded\_t2$, and $prot\_gear\_discarded\_t3$, produced positive and significant coefficients in all tertiles, indicating that $prot\_gear$ NTMs tend to increase exports regardless of the exporter's $discarded$ performance. This initial evidence suggests that these NTMs may not be particularly strict or may not have been adopted with purely protectionist objectives, as argued by trade-oriented countries (JAYADEVAPPA; CHHATRE, 2000; MUNHOZ; VARGAS; VALENTE, 2023). On the other hand, it could imply that some of these flows remain linked to unsustainable practices, such as non-selective and wasteful fishing, since even countries in the lowest performance tertile (t1) experience export growth. Some t1 countries show very low $discarded$ performance and higher standard deviation than countries in other tertiles (Table 6). This outcome suggests that some $prot\_gear$ NTMs should be rethought and redesigned to prevent the import of fish products linked to non-selective practices that result in bycatch and the waste of fishery resources.

Table 7 - Estimation results for fish protection and selective fishing NTMs

Variables	Results
$Fish\_Ag$	-0.437***
	(0.138)
$Tariff$	0.909
	(0.937)
NTM_Others	1.348**
	(0.617)
$prot\_gear\_discarded\_t1$	2.147**
	(0.901)
$prot\_gear\_discarded\ \_t2$	5.152***
	(0.547)
$prot\_gear\_discarded\ \_t3$	4.090***
	(0.604)
$Constant$	9.965***
	(2.364)
Observations	134,576
Adj. R^2	0.9609

Source: Author's elaboration

Although the predominantly positive results suggest that even low-performing countries benefit, the export increase for t1 countries is significantly smaller than for t2 and t3 countries. This finding supports the hypothesis that, while some NTMs may be lenient or poorly designed, lower-performing countries still face relative disadvantages compared to better-performing ones.

In line with expectations, countries in t3 show a much greater increase in trade flows than those in t1, reflecting the idea that countries with stronger environmental performance are more likely to comply with environmental regulations than those with weaker performance (MEALY; TEYTELBOYM, 2022).

The results also show that $prot\_gear$ NTMs may further enhance the trade flows of countries transitioning toward more sustainable fishing practices (t2). This outcome can encourage these countries to continue making improvements since they see gains even during the transition. Favoring the intermediate tertile group can also prevent trade diversion and promote continuous improvement. Such results may be preferable to a scenario where only high-performing countries benefit, failing to promote changes among those with unsustainable practices, who might shift their trade to unregulated markets instead.

Regarding control variables, $Fish\_Ag$, which refers to trade agreements with environmental provisions, yielded negative and significant coefficients. Although trade agreements typically have positive effects in gravity models, environmental provisions can include strict and binding rules. For sample countries, the negative result may imply that these provisions are more rigorous than NTMs in addressing bycatch and harmful fishing practices. NTM_Others, another control variable, was positive and significant. While the literature often classifies NTMs as barriers, their effects can vary by type, sector, product, and the income level of the countries involved. In this case, NTM_Others acts as a control for bilateral NTMs not captured by fixed effects, and for this sample, its effect was positive.

1. CONCLUSIONS

Telecoupled international trade is associated to various forms of environmental harm to fishery resources and marine ecosystems, including overexploitation, threats to biodiversity, and habitat disruptions fueled by practices such as IUU fishing, as well as bycatch and non-selective capture. This study aimed to advance the discussion on the potential of Non-Tariff Measures as environmental governance instruments for telecoupled international trade, using fisheries as a case study. Based on this objective, it was hypothesized that NTMs have sufficient enforcement capacity to make trade flows more environmentally sustainable.

The gravity model was applied to examine the effects of NTMs related to environmentally sustainable fisheries, particularly measures focusing on species protection and selective fishing, across countries at different levels of performance on the indicator measuring fish discards, used as a proxy for bycatch and non-selective fishing practices, and also analyzed CITES-based NTMs on exports of countries grouped by their level of threatened species exports.

The findings confirmed the hypothesis, revealing that NTMs confer smaller benefits – or even reduce trade flows – for countries with lower environmental performance, thereby favoring more sustainable trade flows. Moreover, countries with intermediate environmental performance, which are progressing toward improved sustainability, benefited the most from NTMs. This suggests that well-designed NTMs can foster more sustainable trade by encouraging countries in transition to adopt better practices, preventing them from diverting trade to unregulated markets. Thus, these measures perform an environmental governance role rather than simply rewarding countries already at the highest levels of sustainability.

This study provides a significant empirical contribution to the literature on environmental governance in telecoupled systems by introducing a new instrument capable of making trade more environmentally sustainable. It also contributes to the international trade literature on the effects of NTMs related to the environment, which are often perceived as trade barriers. additionally, it provides a novel and comprehensive database on this type of NTM related to the fisheries sector.

BIBLIOGRAPHY

ACOSTA, C. A. Impending trade suspensions of Caribbean queen conch under CITES: A case study on fishery impacts and potential for stock recovery. FISHERIES, v. 31, n. 12, p. 601–606, dez. 2006.

AGNOSTEVA, D. E.; ANDERSON, J. E.; YOTOV, Y. V. Intra-national trade costs: Assaying regional frictions. European Economic Review, v. 112, p. 32–50, 1 fev. 2019.

AMEPOU, Y. et al. Maw money, maw problems: A lucrative fish maw fishery in Papua New Guinea highlights a global conservation issue driven by Chinese cultural demand. CONSERVATION LETTERS, v. 17, n. 3, maio 2024.

ANDERSON, J. E.; VAN WINCOOP, E. Gravity with gravitas: A solution to the border puzzle. The American Economic Review, v. 93, n. 1, p. 170–192, mar. 2003.

ANDERSON, J. E.; VAN WINCOOP, E. Trade Costs. Journal of Economic Literature, v. 42, n. 3, p. 691–751, set. 2004.

ASIEDU, B. et al. A fishery in distress: An analysis of the small pelagic fishery of Ghana. MARINE POLICY, v. 129, jul. 2021.

AULIYA, M. et al. Challenges of regulating commercial use of marine elapid snakes in the Indo-Pacific. Conservation BiologyJohn Wiley and Sons Inc, , 1 out. 2024.

AYLESWORTH, L.; PHOONSAWAT, R.; VINCENT, A. C. J. Effects of indiscriminate fisheries on a group of small data-poor species in Thailand. ICES JOURNAL OF MARINE SCIENCE, v. 75, n. 2, p. 642–652, mar. 2018.

BACCHETTA, M.; FUGAZZA, M.; GRETHER, J.-M. A Practical guide to trade policy analysis. [s.l: s.n.]. Disponível em: <https://www.researchgate.net/publication/232776748>.

BAIER, S. L.; BERGSTRAND, J. H. Do free trade agreements actually increase members' international trade? Journal of International Economics, v. 71, n. 1, p. 72–95, 8 mar. 2007.

BALDWIN, R.; TAGLIONI, D. NBER WORKING PAPER SERIES GRAVITY FOR DUMMIES AND DUMMIES FOR GRAVITY EQUATIONS Gravity for Dummies and Dummies for Gravity Equations Gravity for dummies and dummies for gravity equations. [s.l: s.n.]. Disponível em: <http://www.nber.org/papers/w12516>.

BIONDO, M. V; BURKI, R. P. A Systematic Review of the Ornamental Fish Trade with Emphasis on Coral Reef Fishes-An Impossible Task. ANIMALS, v. 10, n. 11, nov. 2020.

BISPO, S. Q. A. et al. DA FAZENDA AO MUNDO: COMO A RASTREABILIDADE AFETA O COMÉRCIO INTERNACIONAL DO AGRONEGÓCIO? Texto para Discussão, 2024.

BOOTH, H. et al. Estimating economic losses to small-scale fishers from shark conservation: A hedonic price analysis. CONSERVATION SCIENCE AND PRACTICE, v. 3, n. 9, set. 2021.

CAZE, C. et al. Integrating fishers' knowledge contributions in Marine Science to tackle bycatch in the Bay of Biscay. FRONTIERS IN MARINE SCIENCE, v. 9, dez. 2022.

CHAISSE, J.; CHAKRABORTY, D.; KUMAR, A. SUSTAINABLE SEAS? ASSESSING COMMITMENTS AND IMPLICATIONS OF THE WTO FISHERIES SUBSIDIES AGREEMENT. ASIAN JOURNAL OF WTO & INTERNATIONAL HEALTH LAW AND POLICY, v. 19, n. 1, SI, mar. 2024.

CHENG, I.; WALL, H. J. Controlling for heterogeneity in gravity models of trade and integration. Federal Reserve Bank of St. Louis Working Paper Series, v. 87, n. 1, p. 49–63, 2005.

COHEN, F. P. A.; VALENTI, W. C.; CALADO, R. Traceability Issues in the Trade of Marine Ornamental Species. Reviews in Fisheries Science, v. 21, n. 2, p. 98–111, 2013.

CRAMER, K. L.; KITTINGER, J. N. Reef Conservation off the Hook: Can Market Interventions Make Coral Reef Fisheries More Sustainable? FRONTIERS IN MARINE SCIENCE, v. 8, ago. 2021.

DE MITCHESON, Y. S.; LIU, M.; SUHARTI, S. Gonadal development in a giant threatened reef fish, the humphead wrasse Cheilinus undulatus, and its relationship to international trade. JOURNAL OF FISH BIOLOGY, v. 77, n. 3, p. 706–718, ago. 2010.

DODDEMA, M. et al. Fisher and Trader Responses to Traceability Interventions in Indonesia. SOCIETY & NATURAL RESOURCES, v. 33, n. 10, p. 1232–1251, out. 2020.

EGGER, P. H.; NIGAI, S. Structural gravity with dummies only: Constrained ANOVA-type estimation of gravity models. Journal of International Economics, v. 97, n. 1, p. 86–99, 1 set. 2015.

ERIK, G.; DAGTEKIN, M. Effect of Fishery Closure on Discard Composition of Rapa Whelk, Rapana venosa (Valenciennes 1846) Beam Trawl Fisheries in Black Sea. TURKISH JOURNAL OF FISHERIES AND AQUATIC SCIENCES, v. 22, n. 5, maio 2022.

ESTY, D. C. Bridging the Trade-Environment Divide. Journal of Economic Perspectives, v. 15, n. 3, p. 113–130, 2001.

FANG, Y.; ASCHE, F. Can US import regulations reduce IUU fishing and improve production practices in aquaculture? ECOLOGICAL ECONOMICS, v. 187, set. 2021.

FAO. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome: [s.n.]. Disponível em: <https://www.fao.org/documents/card/en?details=cc0461en>. Acesso em: 9 abr. 2024.

FAO. The State of World Fisheries and Aquaculture 2024 – Blue Transformation in action. [s.l.] FAO, 2024.

FOSTER, S. J. et al. Global seahorse trade defies export bans under CITES action and national legislation. Marine Policy, v. 103, p. 33–41, 1 maio 2019.

FRIEDMAN, K. et al. Examining the impact of CITES listing of sharks and rays in Southeast Asian fisheries. FISH AND FISHERIES, v. 19, n. 4, p. 662–676, jul. 2018.

HAQUE, A. B.; CAVANAGH, R. D.; SPAET, J. L. Y. Fishers' tales-Impact of artisanal fisheries on threatened sharks and rays in the Bay of Bengal, Bangladesh. CONSERVATION SCIENCE AND PRACTICE, v. 4, n. 7, jul. 2022.

HARDIN, G. The Tragedy of the Commons. Science, v. 162, n. 3859, p. 1243–1248, 13 dez. 1968.

HE, J. A Jurisdictional Assessment of International Fisheries Subsidies Disciplines to Combat Illegal, Unreported and Unregulated Fishing. SUSTAINABILITY, v. 14, n. 21, nov. 2022.

HEAD, K.; MAYER, T. Gravity Equations: Workhorse,Toolkit, and Cookbook. In: Handbook of International Economics. [s.l.] Elsevier B.V., 2014. v. 4p. 131–195.

HEID, B.; LARCH, M.; YOTOV, Y. V. Estimating the effects of non-discriminatory trade policies within structural gravity models. Canadian Journal of Economics/Revue canadienne d'économique, v. 54, n. 1, p. 376–409, 1 fev. 2021.

HOLCOMBE, B. E. et al. A framework for the selection of marine aquarium fishes to target for aquaculture. AQUACULTURE, v. 557, ago. 2022.

IBARRA, A. A.; REID, C.; THORPE, A. Neo-liberalism and its impact on overfishing and overcapitalisation in the marine fisheries of Chile, Mexico and Peru. FOOD POLICY, v. 25, n. 5, p. 599–622, out. 2000.

JAYADEVAPPA, R.; CHHATRE, S. International trade and environmental quality: a surveyEcological Economics. [s.l: s.n.]. Disponível em: <www.elsevier.com/locate/ecolecon>.

JIMENEZ, E. A. et al. Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the amazon coast: A case study in the state of Amapa, Brazil. MARINE POLICY, v. 115, maio 2020.

JONES, B. L. et al. Conservation Concerns of Small-Scale Fisheries: By-Catch Impacts of a Shrimp and Finfish Fishery in a Sri Lankan Lagoon. FRONTIERS IN MARINE SCIENCE, v. 5, fev. 2018.

KIM, D. E.; LIM, S. S. Economic impacts of the European Union carding system on global fish trade. MARINE POLICY, v. 165, jul. 2024.

KRAVCHENKO, A. et al. Exploring linkages between non-tariff measures and the sustainable development goals : a global concordance matrix and application to Asia and the Pacific. 20 dez. 2019.

KUO, T. C. et al. Changes in the trade of bycatch species corresponding to CITES regulations: the case of dried seahorse trade in Thailand. Biodiversity and Conservation, v. 27, n. 13, p. 3447–3468, 1 nov. 2018.

KUO, T. C.; VINCENT, A. Assessing the changes in international trade of marine fishes under CITES regulations – A case study of seahorses. Marine Policy, v. 88, p. 48–57, 1 fev. 2018a.

KUO, T.-C.; VINCENT, A. Assessing the changes in international trade of marine fishes under CITES regulations - A case study of seahorses. MARINE POLICY, v. 88, p. 48–57, fev. 2018b.

KURNIA, I. THE PRESERVATION OF MARINE FISHERIES RESOURCES WITHIN ASEAN NATIONS' EEZ. INDONESIA LAW REVIEW, v. 14, n. 1, jan. 2024.

LARCH, M.; LUCKSTEAD, J.; YOTOV, Y. V. Economic sanctions and agricultural trade. American Journal of Agricultural Economics, v. 106, n. 4, p. 1477–1517, 1 ago. 2024.

LE GALLIC, B. The use of trade measures against illicit fishing: Economic and legal considerations. ECOLOGICAL ECONOMICS, v. 64, n. 4, p. 858–866, fev. 2008.

MARTINS, M. M. V. et al. NORMAS VOLUNTÁRIAS DE SUSTENTABILIDADE E SUA IMPORTÂNCIA NO COMÉRCIO INTERNACIONAL. Boletim de Economia e Política Internacional - BEPI, n. 34, p. 1–26, dez. 2022.

MEALY, P.; TEYTELBOYM, A. Economic complexity and the green economy. Research Policy, v. 51, n. 8, 1 out. 2022.

MOROVATI, K. et al. Fishery and agriculture amidst human activities and climate change in the Mekong River: A review of gaps in data and effective approaches towards sustainable development. JOURNAL OF HYDROLOGY, v. 644, nov. 2024.

MOUZAM, S. M. UNESCAP and UNCTAD, Asia-Pacific Trade and Investment Report 2019: Navigating Non-tariff Measures (NTMs) Towards Sustainable Development , United Nations Economic and Social Commission for Asia and the Pacific and United Nations Conference on Trade and Development . Journal of Asian Economic Integration, v. 2, n. 1, p. 119–122, abr. 2020.

MUNHOZ, L.; VARGAS, D.; VALENTE, F. Medidas ambientais e comércio internacional evolução dos princípios ambientais nas disputas comerciais. Observatório de Bioeconomia, p. 1–32, 2023.

NIJMAN, V. CITES-listings, EU eel trade bans and the increase of export of tropical eels out of Indonesia. Marine Policy, v. 58, p. 36–41, 1 ago. 2015.

OSTERBLOM, H.; BODIN, O. Global Cooperation among Diverse Organizations to Reduce Illegal Fishing in the Southern Ocean. CONSERVATION BIOLOGY, v. 26, n. 4, p. 638–648, ago. 2012.

PARKER, R. W. R.; TYEDMERS, P. H. Fuel consumption of global fishing fleets: current understanding and knowledge gaps. FISH AND FISHERIES, v. 16, n. 4, p. 684–696, dez. 2015.

PINCINATO, R. B. M. et al. Market incentives for shark fisheries. MARINE POLICY, v. 139, maio 2022.

PORCHER, I. F.; DARVELL, B. W. Shark Fishing vs. Conservation: Analysis and Synthesis. SUSTAINABILITY, v. 14, n. 15, ago. 2022.

SANTOS SILVA, J. MC.; TENREYO, S. The Log of Gravity. The Review of Economics and Statistics, p. 641–658, 2006.

SARKODIE, S. A.; OWUSU, P. A. Assessment of global fish footprint reveals growing challenges for sustainable production and consumption. MARINE POLLUTION BULLETIN, v. 194, n. A, set. 2023.

SHERMAN, C. S. et al. Guitarfishes are plucked: Undermanaged in global fisheries despite declining populations and high volume of unreported international trade. MARINE POLICY, v. 155, set. 2023.

SHUKLA, A. The Future of Trade and Environment: A Roadmap for Reconciling Two Competing Goals. [s.l: s.n.]. Disponível em: <https://www.wto.org/english/>.

SONG, A. M. et al. Collateral damage? Small-scale fisheries in the global fight against IUU fishing. FISH AND FISHERIES, v. 21, n. 4, p. 831–843, jul. 2020.

SOVACOOL, B. K. A Game of Cat and Fish: How to Restore the Balance in Sustainable Fisheries Management. OCEAN DEVELOPMENT AND INTERNATIONAL LAW, v. 40, n. 1, p. 97–125, 2009.

SUMAILA, U. R.; BELLMANN, C.; TIPPING, A. Fishing for the future: An overview of challenges and opportunities. Marine Policy, v. 69, p. 173–180, 1 jul. 2016.

TIAN, L. T. ASEAN Legal Framework for Cooperation against Illegal, Unreported and Unregulated Fishing (iuu): Significance, Challenges and Proposed Solutions. ASIA-PACIFIC JOURNAL OF OCEAN LAW AND POLICY, v. 9, n. 1, p. 25–45, jul. 2024.

TRIBUZY-NETO, I. DE A. et al. ANALYSIS OF THE ORNAMENTAL FISH EXPORTS FROM THE AMAZON STATE, BRAZIL. BOLETIM DO INSTITUTO DE PESCA, v. 46, n. 4, 2020.

UNCTAD. NON-TARIFF MEASURES TO TRADE: Economic and Policy Issues for Developing Countries. New York and Geneva: [s.n.].

UNCTAD. The Unseen Impact of Non-Tariff Measures: Insights from a new database. Geneva: [s.n.]. Disponível em: <https://unctad.org/system/files/official-document/ditctab2018d2_en.pdf>. Acesso em: 4 jun. 2023.

UNCTAD. TRAINS Online. Disponível em: <https://trainsonline.unctad.org/detailedSearch>. Acesso em: 4 jun. 2023.

VIANNA, G. M. S. et al. Long-Term Fishing Catch and Effort Trends in the Republic of the Marshall Islands, With Emphasis on the Small-Scale Sectors. FRONTIERS IN MARINE SCIENCE, v. 6, jan. 2020.

VINCENT, A. C. J. et al. The role of CITES in the conservation of marine fishes subject to international trade. Fish and Fisheries, v. 15, n. 4, p. 563–592, 1 dez. 2014.

WANG, K.-H.; TSAI, H.-J. The Impact of Globalisation on the Development of International Fisheries Law. SUSTAINABILITY, v. 15, n. 7, abr. 2023.

YE, Y.; GUTIERREZ, N. L. Ending fishery overexploitation by expanding from local successes to globalized solutions. Nature Ecology and Evolution, v. 1, n. 7, 2017.

YOTOV, Y. V. et al. An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model. An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model, 15 nov. 2016.

YOTOV, Y. V. On the role of domestic trade flows for estimating the gravity model of trade. Contemporary Economic Policy, v. 40, n. 3, p. 526–540, 1 jul. 2022.

FINAL CONSIDERATIONS

International trade connects distant regions and actors through flows of goods, information, and resources, yet its environmental implications often remain overlooked. By framing trade as a telecoupled system, this study makes a contribution to the literature, showing that trade is not limited to economic exchanges alone. Instead, it involves a network of socioecological interactions that extend across borders, linking consumption in one location to environmental outcomes in another. Situating trade within the telecoupling framework offers an analytical lens that captures the complexity of these global linkages, enabling more effective approaches to environmental governance.

Fisheries sector offer a compelling case study for this approach. Overfishing, habitat degradation, and non-selective fishing practices such as bycatch threaten marine ecosystems and the long-term availability of resources. NTMs related to species protection and selective gear can potentially reduce these pressures by setting enforceable conditions for market entry. To identify these NTMs, this research creates on a comprehensive and original dataset of NTMs related to environmentally sustainable fisheries, constructed using the UNCTAD database.

This study tested the hypothesis that well-designed NTMs can steer trade flows toward more environmentally sustainable outcomes, focusing on the fisheries sector as a case study. The gravity model was employed to assess the effects of these NTMs on fisheries trade flows, examining whether regulations promoting environmental objectives can indeed steer exports toward more sustainable outcomes.

To further investigate the governance potential of NTMs, interaction variables were created between the NTM vectors (prot_gear and cites) and performance terciles based on indicators of discarded catch (discarded) and endangered species exports (cites_exp). This approach allows the estimation of how NTMs operate under different levels of environmental commitment. The regression results show that countries in lower performance terciles export less than those in higher terciles under NTMs, indicating that environmentally stringent measures discourage trade tied to harmful practices. Moreover, countries in the intermediate tercile benefit most from these measures, experiencing a more pronounced positive effect than those already at higher levels of environmental performance.

These findings confirm that NTMs can function as environmental governance instruments rather than simply benefiting the best performing exporting countries. Thus, this study demonstrates that NTMs not only curb trade linked to harmful practices but also encourage countries in transition to improve their standards. By applying a gravity model, it analyzed NTMs related to species protection and selective fishing practices among countries with varying environmental performance levels. The results demonstrate that NTMs can limit trade linked to environmental harm and foster improvements among countries transitioning to higher sustainability standards, discouraging the shift of harmful practices to unregulated markets.

These findings show that NTMs, when thoughtfully implemented, can serve as effective environmental governance tools. This shifts the focus of governance from rewarding already compliant countries to using trade policy to encourage continuous improvement across a broader range of producers. In doing so, NTMs move beyond conventional views that treat them as mere barriers and highlight their potential as instruments that align trade with environmental objectives.

This dissertation contributes to the literature on telecoupled systems by demonstrating that environmental governance can be strengthened through targeted regulatory measures embedded in trade policies. It advances the discussion on the trade-environment nexus by incorporating an empirical perspective, integrating NTMs into the environmental performance framework, and providing a new, detailed dataset on fisheries-related NTMs. Policymakers can draw on these insights to design NTMs that account for transboundary interactions, promote sustainability transitions, and reduce negative spillovers. Future research could extend these analyses to other sectors and environmental indicators, further examining how NTMs interact with broader governance arrangements, to build more coherent and responsive environmental governance in the era of telecoupled international trade.